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A WORLD OF CHANGE[1]

By Dr. EDWARD R. WEIDLEIN

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THE most interesting address that I could deliver to our radio audience would be to pick out at random from this distinguished group of chemists individual persons and describe their work to illustrate the application of science which has transformed the world. Here are gathered scientists from all parts of the United States, as well as representatives from foreign countries, to exchange ideas, and in their presence it would not take one long to realize that something startlingly new and extremely important is happening in the world.

Their gathering is important, and every university, research organization and industry should be represented. Every chemist realizes that scientists stand upon the shoulders of their predecessors. It is for this reason that their gain is exceptionally rapid. A scientific principle once established becomes the property of all science; a piece of apparatus once constructed becomes a pattern for later apparatus of the same kind.

These leaders in the fields of science are the real authors of history. Their work is having more fundamental effects than all the laws that have been enacted or all the armies that have ever marched in triumph. The benefits that flow from their achievements are not limited by race or creed or political boundaries or even by time. They provide physical comforts for all men and gradually free their bodies from disease and their minds from the terrors of superstitions. They give their fellow scientists enchanting new views into the regions they explore.

That this influence does not die with the individual is clearly illustrated by the life of Charles Frederick Chandler, whose one hundredth birthday will be celebrated at Columbia University in October. Dr. Chandler was one of the founders of the American

[1] Address of the president of the American Chemical Society, Rochester meeting, September 9, 1937.

Chemical Society on April 6, 1876, and served as its president in 1881. He knew how, as few others who have lived, to open the portals of chemistry to a pleasing and attractive vista. He aroused curiosity and ardor. He was a mighty force in the introduction of chemistry into medicine. Wherever we go we find traces of this remarkable man—in industry, in sanitation, in the household and in the improvement, comfort and safety of living. He was a great teacher, and his boys were his constant delight and ever-present care.

If one were to probe the methods of an intent, aproned man busy with the test-tubes, Bunsen burners, flasks and reagents in a chemical laboratory, he would hear a story fashioned of numbers. Strange that the infinite variety of the universe can be resolved into a series of numbers! But to the chemist there is little that is strange about it. Nature has demonstrated that the seemingly endless variety of cosmic phenomena, ranging from microscopic dust particles to gigantic stellar systems, is, after all, superficial. For chemistry has reduced the universe to ninety-two chemical elements or kinds of atoms, starting with simple hydrogen and going up the atomic scale to uranium, the most complex element known. All that we see about us can be resolved into these elements. The fascinating realm of nature, from the log that blazes in one's fireplace to the snow-capped mountain chain that lures in summer, is built up from these elements and their various combinations—evidence of the infinite variety of ways in which atoms and molecules can be joined together. Joined in one way, they make a useful textile; in another, a nourishing food.

Not satisfied with the world as they see it, scientists have set their hands and minds to the task of changing the creations of nature or making new products which nature neglected to make. Nature makes her compounds for general purposes, and is not aware of industrial, scientific nor medical needs. Hence nature is not perfect because not omniprovident, and the chemist often finds it necessary to improve on nature. Already he has prepared artificially a vast number of substances that nature never dreamed of making, including dyes unmatched by any flower, alloys that were not created when the earth was a cooling fiery ball, artificial silk and woolen fibers, stronger drugs and sweeter perfumes wrung from such a surprising source as coal-tar. Many products of life processes and a much larger number of new compounds related to them have been made by the chemist. He is changing life more rapidly and inexorably than ever before, and all about us are heard glowing words about "the new synthetic age."

Our future, to a large extent, is in these innocent-looking but all-powerful test-tubes that you will see neatly arranged, row upon row, in any laboratory.

If Aristotle were living to-day amid our chemical successes, his childhood belief in fairy stories probably would be reborn. The Greek philosopher interpreted the universe in only four elemental forms of matter—earth, air, water and fire. These elements represented the four properties of dryness, cold, wetness and warmth. Thus Aristotle taught that all substances were composed of some sort of primordial stuff in combination with various amounts of the four elementary properties.

Out of Aristotle's doctrine of the elements grew the fascinating but futile work of the alchemists, who dreamed vainly of converting base metals into valuable gold. But, though futile, the efforts of the alchemists were not altogether fruitless. Modern chemistry had its beginnings in the mystical vaporings that characterized their gloomy, dimly lighted workshops, full of strange vessels, spheres, portions of skeletons hanging from the ceiling and massive parchment books covered with hieroglyphics. Alchemy may be compared to the man who told his sons that he had left them gold buried somewhere in his vineyard. The sons dug deeply and earnestly, but found no gold. Their cultivation of the soil, however, produced a plentiful vintage. Similarly, the earnest but unsuccessful search for the transmutation of base metals into gold brought to light many useful discoveries and instructive experiments.

These by-products of alchemy—chance discoveries of chemical elements, compounds and principles—were more important than the search for artificial gold.

The first investigator to grasp the significance of the value of chemistry as a separate science was Robert Boyle, whose publication of "The Skyptical Chymist" in 1661 is often regarded as marking the beginning of modern chemistry. Paracelsus, celebrated by Robert Browning, broke with the monks and alchemists, assailed the physicians who treated chicken-pox with the aid of a soup made of the hearts and livers of vipers and laid crudely the foundation of modern medical chemistry. Becher conceived of phlogiston as the active principle of fire. The downfall of the phlogiston theory began with the work of Joseph Priestley, preacher and scientist, who succeeded in isolating and identifying oxygen.

Before even Priestley, however, was Cavendish, shy, eccentric misanthrope, who played with chemical apparatus and weighed the earth, in preference to spending his wealth, and who won immortality as the first experimenter to reduce water to hydrogen and oxygen. But it was Lavoisier, later snatched from his laboratory by the French police to die under the guillotine, who molded chemistry into a science. The brilliant Frenchman, science's greatest loss to the Reign of Terror, formulated what is now known as the "law of the conservation of matter." This fundamental law states that in every chemical reaction the weight of the

products is exactly equal to the weight of the substances which entered the reaction. Lavoisier also made a list of thirty-three chemical elements, explained the chemistry of fire and infused into the body of science a new spirit for accurate and patient measurement.

To ponder on the future life of man and on the ability of science to mold and reform the future is to lift oneself to a plane of high buoyance. In the words of the Earl of Balfour, in an address he made as president of the British Association, "The satisfaction it gives is almost esthetic in its intensity and quality. We feel the same sort of pleasurable shock as when, from the crest of some melancholy pass, we first see far below us the sudden glory of plain, river and mountain."

What woman or man but is interested in to-morrow? Judged by the scientific marvels of the present day, what an age it will be!

Photographs by radio; machines that seem to think; lights that pierce fog; gas made from water; cameras recording lightning bolts and taking pictures in the dark; five-million-volt guns smashing atoms to wrest new secrets from nature.

News put into type by direct wire; machines to administer anesthetics, record telephone calls, and measure the billionth of an inch; other machines to measure the smoothness of roads and record the nature of accidents; ways to "hear" light and "see" sound.

Fantastic? Yes, but they're here.

These, and more, we have—although our elders would have scoffed if they had been told that these things would come. But a plane roaring from ocean to ocean between sunrise and sunset is nothing new. People talk across the ocean every day by telephone. The time may come when women will match fabrics by television, when their kitchens will make present-day luxury seem like the drudgery our grandmothers endured.

It is impossible, however, to fathom truly what to-morrow may be like. Only the rare human mind can free itself from the fetters of to-day's accepted forms and think in new terms of a different age. The first automobiles were cranked by hand. They broke many an arm, but people accepted the fact because no mechanical way of starting a car could ever work. Yet research, using a sleeve with threads like a screw, found a way to crank the motor; it had never dawned on science that it couldn't be done!

The pace of the advance has quickened. The resources of science, more closely knit, have speeded progress amazingly in the past twenty-five years. That pace will not slacken so long as human needs must be met. If what has happened already seems incredible, what are we likely to see in the not-distant future?

For we know full well that to-morrow probably won't resemble this age in the least. Too many "impossibilities" have come true in our own life-span. We have not yet forgotten that "man will never fly"; that conversing without wires was labeled an absurdity; that "nothing can ever be done" about typhoid, tuberculosis or malaria.

Yet men have flown around the world, talked by wireless across the seas, stamped out plagues. The oxcart has made way for the soaring plane; the laboring locomotive for its silent, streamlined cousin; the mechanical music box for the miracle of radio.

A finger moves a dial and invokes the human voice. But the telephone is an old story. Manufactured ice and mechanical refrigeration come instantly to the rescue in hot midsummer days. But we already forget the waste and illness of the era before man-made refrigeration. The photograph of a distinguished visitor spans the continent in a few seconds. Telephoto, too, however, becomes prosaic. A modern Dryad wears a gown that last year was part of a tree. Yes, but we grow to expect beautiful new fabrics from the commonest substances, even glass.

If yesterday's miracles are to-day's commonplaces, what an age to-morrow may be, with science as its constant guide, insistent on solving human needs, making the improbable come true.

What kind of homes, for instance, shall we be living in by 2000 A.D.? What kind of furnishings shall we have? How shall we heat our homes? Shall we all be living in the country or in some new kind of city? What kinds of recreation shall we have? What kinds of planes, automobiles, trains? What kinds of bridges, tunnels, viaducts, ramps? What materials and substances shall we wear and eat? How much leisure shall we have for the art of living? We dare not more than guess.

For most prophecy is untrustworthy. We all are too likely to project the present into the future, forgetting that the future may go clear around us, or scrap much that we accept. Scientists speak casually of harnessing the winds for power, of drawing upon the heat of the sun, of using even the surge of the tides for power to replace fuel that by then may be gone. Laws will not prevent men from thinking. And so long as they think, so long as they refuse to accept the present age as perfect, advances will be made.

Back of all change is the wholesome spirit of discontent. There must be a way to make a better stocking, to create a more durable fabric, to make a better dust-pan than those now sold. Dissatisfaction with something less than perfection, desires for something better, refusal to accept things as they are—these are the urges that lead to improvement. These, and a special quality of open-mindedness that keeps the present from closing the door to the future.

Chemistry is constantly seeking through research natural facts on which to base new truths, which bring about these changes. But she can not invoke them alone, without the aid of her sister sciences, any one of which may at any moment find a new bit of knowledge which will lead the others along new trails. This world-wide collaboration is really the hope of scientific progress to-day.

Modern research is characterized by its complexity and the variety of phases which it presents. In the latter half of the past century and the beginning of the present, it was still possible for an individual, working alone, with comparatively limited facilities, to achieve epoch-making results in the borderline fields of research. The surface has now been well explored and it is consequently necessary to probe deeper and to enlist the cooperation of trained specialists in such widely diversified fields as chemistry, physics, biology and engineering. Elaborate equipment and apparatus are now required for the conduct of researches, for they must be performed on a mathematically correct basis with constant control of all variables.

There were ages when science moved haltingly or drooped in discouragement beneath the indifference of hostile rulers and superstitious peoples.

To-day the speed of communications alone has woven the world of science more tightly, so that each bit of fresh knowledge is known everywhere as soon as it is proved. It no longer takes months for a new fact or method to filter from nation to nation, or years for it to be practically applied.

Considering the accelerated pace of recent years and the rate at which science has revolutionized our daily lives, it would be easy to sit back complacently and call this an age of scientific miracles, to remark that we had reached the ultimate in development, that there could be no more worlds to conquer.

It would be easy to say it, but your chemist, above all men, could tell you it is not true. He knows that chemistry, though brilliant its gains, has only scratched the surface—knows how pitifully meager is the hoard of knowledge so far acquired. In physics, in chemistry, in engineering, in medicine—the dearth of knowledge is the same. The swift progress that has been made must not make us over-confident and lose us that humility which we must retain if we are to be dispassionate searchers after truth.

If we take the time to glance back through the pages of history, we can see how easily each age has fallen into the error of believing that it represented the ultimate in civilization. There was a time when Europe, steeped in its troubles, guessed of no new land or opportunity like America. The Middle Ages seemed highly developed to its own peoples, but most of the great inventions and discoveries of science have come long since then. Even as late as 1900, millions felt that we had gained as much from science as we were likely to win. Yet in the short span of thirty-five years we have seen the first "red-devil" automobile become a necessity for the masses, turn transportation ideas upside down, revolutionize our industrial structure. We have seen radio burst upon the world and link distant lands by new seven-league boots. We have seen early ventures in flight give another dimension to transport. Television next, and meanwhile scores of new products, new foods, new industries of which, a generation ago, no one guessed. Wonders indeed! Yet science realizes how truly little headway has been made, how much more remains to be done.

Scientific research is still young, even in the life of the universities, which are primarily responsible for its existence. Having gained the spirit of research from the universities, the industries have applied its methods to their own affairs with really amazing results. During the last twenty-five years the number of industrial research laboratories in the United States has grown from a very few to more than two thousand, which accounts for the great change that has taken place in our standard of living. It was chemistry, perhaps more than any other science, that taught business men the true significance of pure and applied research.

Without the evolution of scientific investigations in the universities, industrial laboratories might never have come into existence. Besides the very idea of research, the universities have furnished the industries with men possessing knowledge not only of the underlying scientific facts and theories but of the methods and techniques of investigational work. The man with a true scientific mind is always open to change. From the universities also proceeds much of the basic knowledge of science on which the industries of to-day have been built and which will be the foundation for the industries of the future. Accordingly this essential contributory part of our universities should be recognized and nurtured by the industries. Colleges and schools have invested some $300,000,000 in chemical buildings and equipment. Real progress is made through the cooperation of pure science, industrial research and the industrialists.

The expenditures for industrial research in this country have increased steadily. The chemical industry, the largest cultivator and supporter of research, has enlarged its expenditures on laboratory investigations; the food industry has likewise increased its appropriations for research. The metal-working field, which during the depression stopped much of its research, is now resuming laboratory investigations on a large scale. Researches have lately been accelerated in the fields of building materials, air conditioning,

synthetic fibers, organic chemicals, plastics, "tray" agriculture and new sources of motor fuel.

It may, moreover, be observed that the industries which engaged to the largest extent in scientific research emerged from the depression first and did the most to aid national recovery.

It must be remembered that it is only through applied knowledge that the people have gained the material blessings of our civilization. Every useful agent in our civilization is the product of our industry, and it is only through the industries that these new products of civilization can go to the people. New mechanisms, such as the telegraph, the telephone, the electric light, the x-ray, new medicines, dyes and new alloys come to us only through the industries. We often hear it said that some man eminent in science has "given" his results to the people. That is, in nearly every instance, nonsense. Röntgen's discovery of x-rays, upon which he took out no patents, could go to the people only by the use of x-ray bulbs, and these x-ray bulbs were manufactured and improved by various corporations, through whose factories they went to the people.

The classical example is of course the work of Faraday, on electromagnetic induction, on which is based ultimately the whole immense development of the electrical industry; a development not achieved of course without an enormous amount of capital and directed industrial research.

We are thinking, too, of industry not only depending upon many sciences but being in a real sense science itself. Science pursued in this broad manner will enrich itself and the world. The true manufacturing function consists in making the best thing possible in the most economical way. It does not mean practising the art through the best tradition, but means pursuing the art with the aid of modern scientific knowledge. A good illustration is in the field of synthetic organic chemistry. The development of organic materials of predetermined characteristics to fill definite needs in industry has been employed on a wide scale only in recent years. The more common uses, such as the acetylene flame for cutting or joining metal shapes in the steel industry or the use of glycerol trinitrate or trinitro toluol as detonation agents in mining operations, are generally known. However, a wholly new degree of change is being brought about by interweaving of synthetic organic chemicals with other products. National defense against human aggressors as well as sanitary defense against microorganisms in their modern forms depend largely on synthetic organic chemicals as key products. The modern automobile and airplane, the outstanding accomplishments of the twentieth century to date, would be far from their present standard of excellence without the regulating effect of the synthetic products used in their construction and operation. Anti-knock fuels, special lubricants, durable tires and other rubber goods, anti-freeze materials, lacquer coatings, safety glass, brake fluids, plastic products, among other features, have permitted the remarkable degree of perfection and low cost which these unique products of our generation have attained. A new aliphatic organic chemical industry was created just prior to the depression and has had a rapid and continuous growth since 1929.

Research in the metallurgical industry has resulted in metals without which the production of these new aliphatic organic chemicals, and other processes, needing to be worked at high pressures and high temperatures, would have been impossible.

Chemistry has likewise played a major rôle in the production of better and cheaper motor fuel. Cracking, hydrogenation, polymerization became common terms in the industry. The increasing demand for power plants has resulted in more severe conditions for the lubricants used. Automobile and airplane engine oils are exposed to high temperatures and greater loads each time there is an increase in the horse power yield per cubic inch of cylinder capacity. Under these severe conditions oils are more likely to deteriorate and fail in service. Some progress is being made in the development of addition agents to oils for increasing the oiliness and film strength under severe conditions. By analogy with the well-established practice of adding antioxidants to gasoline to prevent gum formation there is a development under way for adding antioxidants and similar inhibitors to lubricating oils. These may serve to prevent the formation of sludge by oxidation or to prevent corrosion of bearing surfaces, this by some mechanism not yet understood. It is possible that some of these difficulties may be eliminated by change of the engine design so that the lubricants will not be punished so severely. However this may develop, it is interesting to note that chemical research is suggesting a remedy for the engineering difficulty—difficulties caused by over-rapid engineering advances.

Our home construction industry has received much criticism during recent years, and, as the basis of value received for cost and effort, it must be conceded that this criticism is largely deserved. Here is a field that has possibilities of a "world of change." That such a subject has reached the stage of public discussion, however, indicates that improvement has already begun. Our homes may not seem to us to be a chemical project but, in countless applications of plastic materials, quick-drying lacquers and synthetic fibers, we may confidently expect new types of assembly to emerge with greatly reduced costs while giving sanitary, noiseless, fireproof, moisture-proof and vermin-proof construction, in keeping with known possibili-

ties. Let us take a simple example such as a cook-stove. Practically every housewife complains of cooking over a hot stove in the summertime, and conditions are almost as difficult any time during the year. This inconvenience is caused by waste heat, which, if scientifically controlled, would eliminate the discomfort, economize on the fuel bill and also save time. There has recently been constructed a stove along these scientific lines, using both new and old materials, which will give a heat efficiency of 80 per cent. instead of the average yield of 20 per cent. In other words, eight pounds of coal will cook sufficient food for a family of twelve per day. You are quite likely to see on the market in the future a combination coal cookstove and refrigerator in which the waste heat from the cook stove will operate the refrigeration unit. Glassware for cooking purposes has become a common article of commerce, but there was a time when glass was used only for windows and for ornamental purposes. The new tunnel under the Hudson River is to be lined with glass. The first all-glass building was recently constructed in North Carolina, and others are under construction. Glass in fibrous form will find its most wide-spread application as an insulating material for use in construction. Textiles made from glass, because of their resistance to acids, heat and moisture, should find a variety of applications in both homes and industry. It is interesting to observe, however, that some of these new products are the ripening fruit of seeds planted many years ago. New mechanical devices and new application of basic scientific principles have made practicable the evolution of these new products. A good illustration is tempered glass, which was experimented with as early as 1875, and has only recently become a commercial product. The mechanical ice-box did not come into its own until chemistry supplied the proper refrigerants. The home construction industry can hardly yet be said to have started its real race.

It is believed that through orderly and persistent research industry will also be able to absorb much of the surplus crops of American farms. Cellulose is "stored sunshine." The alchemists talked of storing sunshine, the English speculators of the time of John Law floated companies for the purpose, the chemical industry of the future will harness sunshine in the form of agricultural by-products and convert them into useful materials.

A striking aspect of the march of organized research is the emphasis in recent years on staple commodities, particularly those of agricultural origin, as industrial raw materials. New products have naturally been forced to pave their way to public acceptance by technical information obtained in the laboratory. The volumes involved in each case were, of course, at first small, in fact so insignificant that they were disregarded by the industries they were affecting. Change is too often considered as a sudden movement, which is misleading, as it is more often a gradual evolution.

To state the situation another way, new products were continually coming into prominence through the pressure of research, while the materials they were in part displacing lacked the informative background necessary to meet this aggressive competition.

As a tangible example, the case of cotton may be mentioned. All the world is familiar with the giant strides of rayon, its "college-trained" rival. On top of such competition comes the falling off of export volume, as a result of increasing quantities of cotton grown abroad.

Forward-looking men with constructive ideas on means of improving the economic condition of the South see here a great need for a vigorous research program of the cotton industry. Many of our southern states are dependent on this one crop, and their people are trained, their industries are geared to a one-crop economy.

It is significant that developments in increasing the utilization of cotton have in the past been made almost altogether without any concerted action or conscious direction on the part of the cotton industry. This situation encourages one to believe that systematic, cooperative effort on the part of growers, manufacturers and various research organizations, in developing new uses for cotton and in expanding present uses, should be much more effective in stimulating increased demand than haphazard, individual effort.

Sugar is another product that is vital in our national economic and social system. Sugar occupies an important place in the normal diet of all the people. It likewise is one of the cheapest, purest raw materials available upon which to base a new chemical industry. This new industry is now in the process of evolution, and to-day chemicals made from sugar are entering into our industrial processes to produce new and better products.

The scientists are doing the fundamental work. Industry is pioneering the commercialization of these new products, and eventually the agriculturist will have to supply the raw material because of the new demand created. So one often may know where a research begins, but rarely where it will end.

All this requires knowledge, will and action. The knowledge which will find these new uses is a product of research. It will come out of the laboratory where the chemist is breaking down the raw materials we call cotton, sweet potatoes and corn into cellulose and starch and these again into the tiny atoms of which they are constituted. It is these atoms that are the chemist's raw materials. He may buy them in the form of cotton or soybeans or milk, but he sells them in the form of rayon, automobile parts, organic acids, new glues and gums and dextrins, new building mate-

rials for our homes, new paints and varnishes. These new uses require as raw materials the molecular aggregates which we take off the land in annual crops. It is true that the chemist can synthesize them in his laboratory, and some of them he will undoubtedly produce there, but this year and for many years to come the sunshine and the rain, the fertility of our soils and the patient labor of our farmers will grow the crops industry needs more cheaply than the chemist can make them.

The better living conditions secured through the increased wealth provided by science, together with the application of science to hygiene and medicine, have considerably increased the average expectancy of life. This great achievement in public health is sufficient to justify the belief that those who call our industrial civilization mean in quality have narrow views and scant idealism.

Chemistry and medicine are establishing a more cooperative program of research, and a good example is some work that has been under way since 1926 on the treatment of pneumonia.

The results of this teamwork between chemists and medical scientists have been of outstanding importance. Woven throughout the whole progress of the investigation is ample human drama cloaked from the layman by such chemical names as hydroxyethylhydrocupreine, apocupreine, ethylapocupreine, hydroxyethylapocupreine and other necessarily abstruse terms. Briefly, the problem was less to find a compound effective with pneumonia and allied diseases than to find one that would not harm the eyes. Certain of the cinchona alkaloids were known to be effective in treating pneumonia, but they were not to be used without great probability of eye damage. Such a dilemma is, of course, a challenge to the chemist and to the physician. The results so far indicate the discovery of cinchona alkaloid derivatives, as new compounds, which give the profession of medicine what it has long sought—a safe treatment of all types of pneumonia which will not harm the human eye and therefore can be both effective and safe.

To date, close to eighty preparations have been tested biologically by the medical collaborators. Some were found to cause no eye disturbance, but to have little activity with pneumonia. The most promising drug found, showing greater activity against the disease, lower toxicity than any of the others, has also been tested in scores of clinical cases, which have demonstrated a very high tolerance in the human being to the drug, absence of any untoward visual results and a high proportion of recoveries from severe pneumococcic infections of all types.

The investigations must go on, the clinical trials must be conducted on a wider base, production of the compound on a large scale must be undertaken. All these projects are now under way, and the chances of ultimate success are very promising.

When trained minds and proper facilities are applied to specific problems, practical solutions are expected. If they were not forthcoming—that would be news.

Fifty years ago, Europe led the world, chemically speaking. Far-seeing men predicted even then that in another half-turn of the century the chemical leadership of the world would pass to America. This change has come about, and the American Chemical Society as an organization deserves a large share of the credit. The scientists of each nation have worked with might and main to surpass one another in chemical discoveries; and the advantage that we have gained has been largely due to the cooperative spirit generated by our society activities. A nation must be able to stand chemically alone unless it would be subservient, so utterly does present-day civilization depend upon chemistry for a thousand-and-one everyday foods and materials. And it grows more and more apparent that to help one's country to be chemically independent is the profoundest kind of patriotism.

The objective of scientific research to-day, moreover, is broader than the solution of technological and chemical problems. It takes into its view the responsibility for enlivening the imagination of the masses who will be the chief beneficiaries of these new ways of living.

A true scientist never grows old in his way of thinking. His mind is constantly working to improve his surroundings and to better understand the laws of nature. He expects to live in a changing world.

RÔLE OF ARTESIAN WATERS IN FORMING THE CAROLINA BAYS

By Professor DOUGLAS JOHNSON
COLUMBIA UNIVERSITY

IN an earlier issue of SCIENCE the writer advanced evidence in support of the hypothesis that oval bays of the Carolina coast and adjacent regions were basins of former lakes, that the basins resulted in part from the solution of limestones or other soluble beds underlying surface sands of the coastal plain, and that the rims partially encircling the basins were accumulations of wind-blown sand. In this paper it was shown that

subsidence of overlying sand or sandy loam into relatively small and irregular sink-holes would produce relatively large and symmetrical surface basins; that the so-called "sinks" would serve not only to receive waters descending from above, but also in many cases to discharge waters rising from below; and that these upwelling waters might be an important factor in producing the oval basins. It was fully realized that the oval basins or "bays" occurred in areas where limestone was not known to exist; but it was shown that the solution of alumina, iron and other soluble constituents of non-calcareous beds was known to have produced sink-holes in this general region.

Further studies of the problem of bay origin have convinced the writer not only that the upwelling waters in regions of karst topography in the coastal plain are often artesian in their nature, but that the rôle of artesian waters in forming oval bays has been of major importance. These waters circulate most freely where solution of limestones, marls, arkosic sandstones and other soluble beds opens passageways of appreciable size; but they also pass readily through coarse siliceous sands and deposits of gravel in which solution is negligible. Thus while most of the oval bays occur in regions of soluble rocks, they are also found in localities underlain by notable deposits of coarse sand and gravel.

The hypothesis of bay origin previously advanced by the writer, expanded to emphasize more fully the important rôle played by upwelling waters, may be restated somewhat fully as follows:

As the Atlantic Coastal Plain emerged from beneath the ocean, rainfall gave rise to surface streams which flowed approximately northwest to southeast down the surface slope, and to an underground circulation which moved through the sediments in general from northwest to southeast down the dip of the beds. The Coastal Plain formations consist of lenses of sands, gravels and other pervious deposits, alternating and interfingering with lenses of clay and other impervious beds. Hence water entering pervious layers higher up the slope often migrated seaward between impervious layers under ever increasing pressure. Where wells tap the pervious layers and the contained water is under sufficient pressure, artesian flows of water are secured at the surface. In many cases, however, the imprisoned underground water did not proceed far before it found means of escape to the surface, whether because an overlying lense of impervious material had thinned out and disappeared or for some other reason. This water, welling up from below under moderate pressure, created over vast areas of the Coastal Plain what might be called "artesian springs," since the conditions of flow were exactly similar to those of artesian wells, except that in the latter case the passageways to the surface are artificially created.

Before the surface streams had entrenched themselves deeply into the Coastal Plain, thus affording opportunity for underground waters to escape at lower levels, the outflow of "artesian springs" on the nearly flat Coastal Plain surface was a phenomenon of major importance. Locally its importance may have increased greatly as time went on, due to the fact that flow of water through limestone, marl, feldspathic sands and other soluble materials developed underground passages which much facilitated further water movement. We should picture vast stretches of the Coastal Plain having the surface dotted with literally countless springs, many so small that their waters might filter away through the surrounding soil; others so large that copious streams flowed from them in definite channels they had carved for their escape; and all "boiling" or "fountaining" in greater or less degree, due to the artesian pressure of water entering the sediments farther up the Coastal Plain slope. Other large portions of the Coastal Plain surface had few or no such springs, because impervious layers near the surface or other unfavorable geological conditions constrained the waters to continue underground until they reached areas where escape to the surface was easy.

The immediate surface layer of the Coastal Plain was then, as now, prevailingly of sand, whether because surface weathering and wash had produced a residue of quartz grains from the decomposition of surface formations, or because advance and retreat of the sea had left a coating of wave-washed sand. Immediately below the loose surface sand there was usually a loamy sand or sandy loam. Because surface streams were not yet deeply entrenched, the groundwater level must at that time have been very close to the surface of the plain. Consequently the upwelling "artesian springs" reached the surface in a layer of loose sand or sandy loam effectively saturated with water.

Where springs are active in saturated sand or loam two things are apt to occur. The escaping waters carry away some of the sand, especially the finer grains, and much of all of the clay and silt contained in the loam. Thus a cavity or depression in the surface is formed. Toward this depression saturated loose sand slumps or flows freely inward from all directions, while sandy loam disintegrates and moves more slowly. Thus there develops a progressively enlarging more or less rounded basin, and the spring is transformed first into a pool, then into a lake, on the bottom of which the upwelling waters may be seen making the sand to "boil." It is believed that countless such lakes developed on the surface of the undissected Coastal Plain where superficial sand or sandy

loam was saturated by a high-standing groundwater level and where subsurface waters, previously migrating seaward under pressure beneath an overlying impervious formation, found ready escape to the surface. Where the surface was underlain by loam containing a high percentage of clay, or by some other relatively compact or impervious formation; and where geological conditions underground did not bring to a given region abundant supplies of water under artesian pressure, springs were rare or absent, and lakes of the type described failed to develop.

Where the surface was underlain by soluble formations, such as limestone, marl or arkosic sands, progressive solution developed channels or caverns underground and sink-holes and similar karst phenomena on the surface. Some sink-holes would result directly from the solvent action of descending local rain water. Others may have resulted from the caving in of underground channels and caverns in the soluble beds, while still others were developed by waters upwelling to the surface. The resulting "sinks" served in part as intakes for descending surface waters, and in part as exits for uprising artesian waters, depending upon local conditions. The same openings might serve first one purpose, then the other, as changes in groundwater level, underground circulation and other local conditions varied.

In localities where compact material was at or close to the surface, sink-holes would exhibit the irregular outlines commonly observed in limestone regions, and many of them might be of very small size and relatively deep. But where the soluble formation was buried under a thick cover of loose sand, the surface depressions would tend to be comparatively shallow, circular or oval in outline, and even the smaller examples of relatively large diameter. This is because loose sand slumping into a cavity moves obliquely inward from all sides, with the result that the surface depression may have a diameter many times that of the cavity into which the sand below slumps; while the irregular outlines of the smaller opening are practically lost in the greatly enlarged outline at the surface. The subsidence crater thus produced in loose sand will be scarcely perceptible if the quantity of material slumping into the underlying cavity is small, while even a large amount of underground slumping will leave a surface crater relatively shallow. A deep crater in the overlying sand could be produced only in the improbable event that great quantities of the material were carried off through underground passageways and effectually disposed of where it could not impede continued sand removal. Relatively large, shallow, regular craters would be the rule, circular in outline unless the underground cavity were notably elongated, oval in the latter case. Craters originally round might later become oval, for reasons to be discussed fully in a later publication.

We have seen that the groundwater level must have been close to the surface of the plain prior to incision of stream valleys. This would have two important consequences for subsidence craters in loose sand. First, thoroughly saturated loose sand would flow inward toward the depressions from greater distances, increasing the diameter of the craters and rendering them more shallow. Second, the craters would hold lakes wherever and so long as the groundwater level was sufficiently high. Where compact clayey loam or other resistant material slumped as the result of removal of underlying soluble material, the surface depressions would not necessarily be much larger than the areas of slumping below, and might retain highly irregular outlines. In such depressions irregular lakes, large or small according to the extent of underground solution and slumping, would persist where and when the groundwater level was high.

Across the countless lakes formed by "artesian springs" upwelling in sand and loam and by subsidence of sand and other material into solution cavities, the winds drove waves and currents which attacked the shores of the lakes and moved material along their borders. Due to wave refraction, and in obedience to the law that irregularities of youthful shores tend to become smooth in the stages of submaturity, maturity and old age, irregularities of the lake-shores would tend in time to disappear, and the lakes thus acquire rounded or oval outlines. The transformation would take place quickly where the lake basins had formed in loose sand, especially if the initial outline of the lake were fairly simple, with only minor irregularities. Where a lake basin with minor irregularities was developed in loam, or where, as might occasionally happen, a lake basin formed in loose sand had shore irregularities of large magnitude, the attainment of the simpler form would be long delayed. And where a highly irregular basin was formed in clayey loam or more resistant material, the shore irregularities might not be reduced before the lake was extinguished by down-cutting of the outlet, by filling of the basin or by some other process.

It appears that vast numbers of the Coastal Plain lakes were quickly reduced to oval forms, but that some retained a greater or less degree of irregularity, while others continued highly irregular. This accords well with the fact that the lakes developed under a variety of geological conditions.

Wave work on the shores of the lake in time developed sandy beaches, quickly where loose sand was already available, more slowly where sandy loam had to be reworked and sand separated from silt and clay. Sometimes waves and currents transported sand along shore, building bars across the mouths of re-entrant

bays or in front of the somewhat sharper curves at the ends of the oval basins.

Whenever the sand cast upon the lake-shore beaches was dry, it was subject to transportation by the winds. Thus it happened that ridges of wind-blown sand accumulated on the upper parts of the beaches, transforming beach ridges into dune ridges which encroached upon the land immediately to the rear of the beaches. On small lakes the beaches were characteristically insignificant features; but there was no limit to the height and breadth that the dune ridges replacing them might acquire. Often the sand from the beaches was carried up over the rim of the crater and accumulated as a dune ridge resting upon the Coastal Plain strata at the crater's edge.

Before streams had incised their valleys below the nearly flat surface of the Coastal Plain, the groundwater level or water table must have been fairly constant in its position close to the plain surface. But as stream valleys were deepened, conditions changed. At wide intervals underground waters found opportunity to escape into major streams at levels well below the surface of the plain. Near the valleys the water table was permanently lowered, so far indeed that lakes near the rivers must have gone dry, and their basins have become subject to dissection by minor streams gnawing headward from the valleys into the adjacent upland. Farther away from the valleys, and especially in the central portions of the broad, undissected interstream areas, the lowering of the water table was much less pronounced. Here lakes may long have persisted in the craters, even where lake levels were permanently lowered. Under the new conditions temporary fluctuations in the groundwater level must have developed, the water table rising during periods of abundant rains and falling during periods of drought. This would cause lake levels to fluctuate, with the result that sandy beaches might form at different levels at different times, while beaches dry at one period might be wet or submerged at another.

As solution of limestone and other soluble formations progressed, another type of change affected the lakes. Subterranean passageways were gradually enlarged, and new channels and connections were opened from time to time. These changes in soluble formations caused changes in the circulation of underground waters, which in turn affected the position of the water table. When such changes were gradual lake levels may have shifted gradually; but the sudden opening of a new underground connection between passageways may well have caused a sudden rise or fall of lake surfaces. Beach formation and the development of dune ridges would thus be suddenly shifted from one level to another.

Progressive deepening of river valleys and progressive development of underground channels connecting eventually with the ever deepening streams, tended toward one end—the ultimate extinction of the lakes through lowering of the groundwater level below the bottoms of the lake basins. To the same end operated the filling of lake basins with marshy deposits and peat. In time most of the lakes were transformed into dry depressions or into marshy basins called "bays." Relatively few basins, specially favored by local conditions, still contain open lakes. In time they too will be drained or filled; and ultimately the progressive dissection of the Coastal Plain by headward growing branches of the major streams will destroy every trace of the countless basins and their contained lakes which once diversified broad areas of the Coastal Plain surface.

Such is the history of the initiation, development and extinction of the curious Carolina bays, according to what may be called "the hypothesis of complex origin," since it involves artesian, solution, lacustrine and aeolian factors. It remains to test the validity of this hypothesis: first, by determining whether it will adequately account for the many facts concerning the bays already reported in the literature of the subject; and second, by deducing as fully as may be the reasonable consequences of the hypothesis, and then ascertaining whether newly discovered and previously recorded facts correspond to the consequences thus deduced. To this task the writer has for some time devoted his attention, and the results will be published at an early date.

OBITUARY

HERMAN DIEDERICHS

HERMAN DIEDERICHS, dean of the College of Engineering of Cornell University, died on August 31 at the age of sixty-three years.

For forty-four years Dean Diederichs, whose career began as a poor German immigrant boy, has been identified with Cornell University as a student, teacher and, since July 1, 1936, as dean of the engineering college.

He was regarded as an authority in experimental engineering with special reference to materials of engineering. His text-book, in collaboration with the late Professor R. C. Carpenter, published in 1910, is standard in the field. He is co-author with W. C. Andrae of a monumental work on mechanical experimental engineering, dealing with engineering instruments, published in 1931.

A prolific writer, he was co-author of three bul-

letins of the Engineering Experiment Station at Cornell and with W. D. Pomeroy, of Seneca Falls, was a winner in 1930 of the Melville Medal of the American Society of Mechanical Engineers for a "thesis of exceptional merit." He had performed many investigations and tests as a consultant in private industry.

Throughout his career on the faculty of Cornell University, Dean Diederichs maintained his interest in student activities, particularly in athletics. Elected in 1907 as track adviser for the athletic association, he became its president in 1913 and served through 1925, being elected again in 1932 and serving until he became chairman of the new board of athletic control. He was known as the father of the regional scholarship plan of the athletic association.

In recognition of his many years of service to his alma mater, as student, teacher and administrator, the class of 1935 designated him as "Cornell's Man of the Year" in dedicating its classbook to him. He was a member of Quill and Dagger, senior honorary society; Tau Beta Pi, Phi Kappa Phi and Phi Sigma Kappa fraternities, and belonged to such professional societies as the American Society of Mechanical Engineers, the Society of Automotive Engineers, the Society for the Promotion of Engineering Education, the German Society of Engineers and the American Society for Metals.

A CORRESPONDENT

LORD ROTHSCHILD, FOUNDER OF THE ZOOLOGICAL MUSEUM AT TRING

LORD ROTHSCHILD, founder of the Zoological Museum at Tring, England, which is considered the finest privately owned institution of its kind in the world, died on August 27 at the age of sixty-nine years. Before his illness he took the chief part in the management of his museum, and was accustomed to work side by side with members of his staff cataloguing new specimens which were continually arriving from all parts of the world. In addition he also maintained at Tring a large private zoological garden.

In an account of his life and work the London *Times* writes:

> Since his earliest days Lord Rothschild had been devoted to zoological science, and it was his boyish hobby of collecting butterflies that led to the founding of his museum. Before the War the collection was stated to be the largest of its kind in the world, and through the years it continued to increase. The reason of its rapid growth was the necessity Lord Rothschild found of accumulating not merely specimens of a creature from every part of its habitat, but of obtaining a very large number of specimens of each individual kind. The scope of the museum was very wide. Many thousands of mammals, birds, fishes and reptiles were mounted in the spacious buildings designed to house them. A description of the museum in detail would fill volumes. Exhibits traced the development of species and included examples of extinct or disappearing animals, in addition to which there was an exceptional collection of horns from all over the world. Between 1,000,000 and 2,000,000 butterflies were in the departments to which Lord Rothschild was specially devoted and concerning which he had been the largest contributor to our knowledge.
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> Ornithologists learned with dismay in 1932 that the collection of birds, an outstanding department of the museum, had been sold and was going to the United States. The reasons given for that step were the heavy burden of maintaining a private museum and the consequent necessity of disposing of part of it. The choice lay between the sale of the birds or the sale of an even more complete collection of insects. Lord Rothschild chose to dispose of the former. The collection of birds was particularly rich in "types." In modern systematic zoology, when a new species is described, in addition to the publication of an adequate diagnosis, preferably with a figure, an actual individual specimen is selected by the author of the species and its registered number in a private or public collection is stated. This selected example is known as a "type" which acquires a high money value as well as scientific interest.
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> Lord Rothschild wrote numerous articles on zoology; was the author of "Avifauna of Laysan," and was the joint editor of "Novitates Zoologicae"—published at the Zoological Museum, Tring. In 1911 he was elected a Fellow of the Royal Society and he had been a trustee of the British Museum since 1899.

RECENT DEATHS AND MEMORIALS

DR. HUGH D. REED, head of the department of zoology of Cornell University, died suddenly on August 23 at the age of sixty-two years.

PROFESSOR EDSON FORBES HITCHINGS, from 1905 to 1911 state entomologist of Maine and later, until his resignation in 1918 on account of ill health, in charge of the department of horticulture in the University of Maine, died on September 8 at the age of eighty-four years.

DR. JAMES NATHANIEL JENNE, for the last ten years dean of medicine at the University of Vermont, died on September 9. He was seventy-seven years old.

PROFESSOR J. E. DUERDEN, head of the Wool Industries Research Association in Leeds; honorary fellow in zoology of the University of Leeds, and an honorary curator of the American Museum of Natural History in New York City, died on September 4 at the age of sixty-two years.

Nature announces the death of Professor Josef Woldřich, director of the State Geological Institute at Prague; of A. Sharples, formerly government mycologist of the Federated Malay States and head of the

Division of Plant Pathology at the Institute of Malaya, and of Professor Hans Reck, the distinguished German volcanologist.

THE bicentenary of the birth of Galvani will be celebrated at the University of Bologna on October 18.

The British Medical Journal reports that a memorial to William and John Hunter was unveiled in East Kilbride Public Park on July 28 by Sir Hector J. W. Hetherington, principal of the University of Glasgow. It bears a relief symbolic carving with the inscription: "To the memory of William Hunter, M.D., F.R.S., 1718–1783, and John Hunter, F.R.S., 1728–1793. They were born at Long Calderwood, and died in London after attaining the highest eminence in the sciences of medicine and biology. Their names will be held in reverent remembrance by a grateful posterity to all generations."

SCIENTIFIC EVENTS

THE SILVER JUBILEE OF THE INDIAN SCIENCE CONGRESS ASSOCIATION

Nature gives an account of the twenty-fifth annual session of the Indian Science Congress Association, which will be held in Calcutta from January 3 to 9, under the presidency of the Right Hon. Lord Rutherford. To mark the silver jubilee of the association, the meeting is to be a joint session with the British Association. About a hundred men of science have been invited from Great Britain, while invitations have also been extended to a number of scientific workers in other countries. The congress will be divided into the following sections under the presidents named: (1) Mathematics and Physics, Dr. C. W. B. Normand, director-general of observatories, Meteorological Office, Poona 5; (2) Chemistry, Professor S. S. Bhatnagar, director, University Chemical Laboratories, Lahore; (3) Geology, D. N. Wadia, officiating superintending geologist, Geological Survey of India, Calcutta; (4) Geography and Geodesy, Dr. A. M. Heron, director, Geological Survey of India, Calcutta; (5) Botany, Professor B. Sahni, professor of botany, University of Lucknow; (6) Zoology, Professor G. Matthai, professor of zoology, Government College, Lahore; (7) Entomology, M. Afzal Husain, principal, Punjab Agricultural College, Lyallpur, Punjab; (8) Anthropology, Dr. B. S. Guha, Zoological Survey of India, Indian Museum, Calcutta; (9) Agriculture, Rao Bahadur T. S. Venkatraman, Imperial sugarcane expert, Lawley Road, Coimbatore; (10) Medical Research, Sir Upendranath Brahmachari, professor of tropical medicine, Carmichael Medical College, Calcutta, and honorary professor of bio-chemistry, University of Calcutta; (11) Veterinary Research, Sir Arthur Olver, animal husbandry expert, Imperial Council of Agricultural Research, New Delhi; (12) Physiology, Colonel R. N. Chopra, officiating director and professor of pharmacology, School of Tropical Medicine, Calcutta; (13) Psychology, Dr. G. Bose, University College of Science, Calcutta. The main part of the British Association delegation will arrive at Bombay on December 16, and will tour Northern India before attending the congress. The address of the General Secretary of the Indian Science Congress Association is c/o The Geological Survey of India, 27 Chowringhee, Calcutta.

RELIEF MAP OF THE ROCKY MOUNTAINS AND PACIFIC COAST STATES

A LARGE accurate scale relief map, costing more than a million dollars, is planned as one of the attractions of the 1939 Golden Gate International Exposition on San Francisco Bay.

It is expected that this map, measuring 100 by 150 feet, will occupy the court of the Hall of the Western States. Built on a scale of one inch to the mile with a 2½-to-3 exaggeration of contours, the map will depict every depression and elevation in the Rocky Mountains and Pacific Coast States, an area of 1,189,141 square miles.

The proposed map promises to be of invaluable aid to agricultural, lumber, oil, mining, power interests and to business in general. Various stands of timber throughout the west will be indicated by different shades of green, while other colors will be used to differentiate farming, grazing areas and barren land. Watersheds, drainage, hydro-electric projects and highways will also be shown. Undoubtedly the map will prove a definite aid in fire-fighting, forest conservation, crop, pest and soil erosion control, mineral surveys and in engineering new roads through mountainous regions.

This project is the outgrowth of work now being carried on by the U. S. Forest Service, which has completed many individual sections of the western forest area. Fifty-foot contours are built up by tracing projection lines and cutting them out of chipboard by electric machines. The chipboard map is then shellacked and covered with molding clay for casting.

Although a map of such proportions will prove a spectacular attraction at the exposition, the real justification for such a project will come from its value to many state and government agencies which will be able to procure duplicate casts of the original at relatively small expense. By painting and decorative treatment, each department using a replica will be able to emphasize the scope of its interest by the indi-

cation of highways, forests, rivers, minerals or other data.

This project, sponsored by the California Department of Natural Resources and approved by several government agencies, is now awaiting final authorization from Washington. The first unit of the complete western states map, the California section, is already two thirds completed. Started by the U. S. Forest Service under the direction of H. A. Siedelmeyer, the work is now being carried on by the WPA. Approximately a hundred men are engaged on this section, which has been under construction for the last two years.

If the project is enlarged under federal direction to include the eleven Western States, Mr. Siedelmeyer will be lent by the U. S. Forest Service to take charge of this work.

THE SIXTEENTH EXPOSITION OF CHEMICAL INDUSTRIES

THE sixteenth Exposition of Chemical Industries will be held at the Grand Central Palace, New York City, from December 6 to 11. In addition to the many exhibits of chemicals and chemical products, there will be displays of plant equipment and chemical process machinery of advanced design. Purity and uniformity of product, low cost production and efficiency in the handling of materials will be emphasized and modern methods for meeting the needs of the unit process industries of chemical engineering will be demonstrated.

The exhibits will include general plant equipment and machinery in terms of unit processes of chemical engineering. High vacuum pumps, liquid pumps, compressors and blowers for the chemical industry will be exhibited in the plant equipment section. Bottling equipment will be supplemented by mixing and storage tanks, pumps, filters, mixers, labelers and cappers.

Instruments of precision which safeguard the operation and control of all chemical engineering processes will constitute an important section. Indicating and controlling instruments will include those for temperature, pressure, humidity and the flow of fluids. Other instruments to be displayed are portable and wall-type indicating pyrometers, resistance thermometers, pyrometer controllers, direct reading air velocity meters, industrial thermometers, oil testing instruments, chemical thermometers and hydrometers.

The rôle of metals and alloys in chemical engineering construction and in the processes of industrial chemistry will be represented by comprehensive exhibits of steel and corrosion-resistant alloys, likewise by the non-ferrous metals such as copper, brass and bronze. For those interested in the fabrication of chemical plant equipment there will be an exhibit to demonstrate the weldability of stainless steels. Other items in the metals section will include tubing for a variety of chemical plant installations, woven wire fabrics, wire rope, cable. Tubing, couplings and valves, in brass, aluminum alloy, steel and nickel will be shown in all sizes for process operations over the complete range of pressure and temperature conditions.

Materials handling equipment will demonstrate the labor-saving features and space-saving advantages attainable in modern warehousing. With the latest equipment, which will be on display, unnecessary handling and rehandling, piling and repiling is eliminated.

ROCKEFELLER TRAVELING FELLOWSHIPS

THE British Medical Research Council has awarded Rockefeller fellowships to the following for the academic year 1937–38:

Dermid Lockhart Cameron Bingham, clinical tutor, Surgical Out-patient Department, Royal Infirmary, Edinburgh.

Eric George Lapthorne Bywaters, assistant clinical pathologist, Middlesex Hospital.

Philip Rainsford Evans, registrar, Medical Diseases of Children, King's College Hospital, London.

John George Selater, tutor in clinical medicine, Royal Infirmary, Edinburgh.

Eric Frank Scowen, assistant director, Medical Professorial Unit, St. Bartholomew's Hospital, London.

Charles Herbert Stuart-Harris, Sir Henry Royce research fellow in influenza, London.

Graham William Hayward, resident medical officer, National Hospital for Diseases of the Heart, London.

All the fellows propose to work at centers in the United States. Dr. Stuart-Harris and Dr. Hayward will hold their fellowships under modified conditions, while receiving emoluments from other sources.

In addition, the Rockefeller Foundation has awarded fellowships, on the recommendation of the Medical Research Council, to the following candidates in the special field of psychiatry, neurology and related subjects:

Edward William Anderson, medical director, Cassel Hospital, Penshurst.

Alexander Kennedy, assistant medical officer, Maudsley Hospital, London.

Alan Sutcliffe Kerr, surgical registrar, Royal Infirmary, Liverpool.

Denis John Williams, resident medical officer, Hospital for Nervous Diseases, Maida Vale, London.

Alexander Francis Rawdon-Smith, senior student, Royal Commissioners for the Exhibition of 1851, working

in the Psychological Laboratory at the University of Cambridge.

Dr. Anderson proposes to work in Germany, the others at centers in the United States. Dr. Rawdon-Smith will hold his fellowship for six months only.

FIRST AWARD OF THE FRANCIS P. GARVAN MEDAL

DR. EMMA P. CARR, head of the department of chemistry at Mt. Holyoke College, was awarded on September 8 the first Francis P. Garvan Gold Medal, established "to honor outstanding women chemists." Of those starred in American Men of Science 4.6 per cent. are women. The award, announced by the American Chemical Society at its ninety-fourth meeting, was given to Dr. Carr in recognition of "her work in physical chemistry, especially on the structure of organic molecules by means of absorption studies in the far ultra-violet portion of the spectrum."

According to the Committee of Award, of which Dean Frank C. Whitmore, of Pennsylvania State College, president-elect of the society, was chairman, Dr. Carr has become an authority in this field of chemistry. She developed at Mt. Holyoke an unusual research technique in which organic chemists, physical chemists and physicists cooperate closely.

Dr. Carr, now in San Francisco, will sail soon for Australia on an educational mission. A paper describing the results of her work and that of her coworkers was read by Professor Mary L. Sherrill, of Mt. Holyoke College, before the Division of Organic Chemistry. The report confirmed the configuration of two different forms of hydrocarbon molecules, the principal constituents of gasoline. By means of absorption spectra, the theory of the structure of the cis and trans 2-butene isomers, or compounds with an identical number of hydrogen and carbon atoms but different arrangement of atoms around the double bond, was borne out. Dr. Carr has also identified for the first time the pure cis and trans isomers of 2-pentene, a third hydrocarbon molecule. This additional data of a purely scientific nature will aid the petroleum chemist. Dr. Carr's reported researches have dealt with the energy relationships of the hydrocarbon molecules, especially of the double bond, involving the olefins.

Dr. Carr was born in Holmesville, Ohio, in 1880. She began the study of chemistry under Professor William McPherson, of the Ohio State University, continuing at Mt. Holyoke College and at the University of Chicago. From the latter institution she received the degrees of bachelor of science and doctor of philosophy, studying under Dr. Julius Stieglitz.

She became head of the department of chemistry at Mt. Holyoke in 1913 after some years of teaching and research and began her spectrographic work in 1919. She has traveled widely, and has carried on research under A. W. Stewart in Belfast, Ireland, and Victor Henri, of the University of Zurich, Switzerland. Last year she was delegate from the National Research Council to the International Chemistry Union meeting in Lucerne.

The work of Dr. Carr and her associates at Mt. Holyoke has been supported by the National Research Council, which provided a vacuum spectrograph and technical assistance, and by the Rockefeller Foundation, which has granted financial aid for absorption spectra research with unsaturated hydrocarbons. The medal will be formally presented to Dr. Carr at the ninety-fifth meeting of the society at Dallas, Texas, on April 18, 1938.

SCIENTIFIC NOTES AND NEWS

DR. SIMON FLEXNER, director-emeritus of the laboratories of the Rockefeller Institute for Medical Research, will sail for England on September 25 to take up his work as Eastman visiting professor at the University of Oxford.

DR. JAMES ROWLAND ANGELL, formerly professor of psychology at the University of Chicago and later president of Yale University, recently appointed educational director of the National Broadcasting Company, will leave for Europe early in October. He will make a study of educational broadcasting in England, Belgium, Holland and the Scandinavian countries.

DR. LOUIS MARTIN, director of the Pasteur Institute, has been elected a member of the French Academy of Sciences to succeed Dr. Jean Charcot, who was drowned when the *Pourquoi Pas?* foundered off the coast of Iceland. Dr. Charcot is succeeded in the French Academy of Medicine by the author Dr. Georges Duhamel.

PRESENTATION of the first German national prizes, established in 1936 as a substitute for the Nobel prizes as part of the protest of the German Government against the award of the Nobel peace prize to Carl von Ossietzky that year, was made on September 7 at a cultural session of the Nazi Party Congress. A prize of $40,000 was awarded to Dr. Alfred Rosenberg, official philosopher of national socialism; one prize was divided between Professor August Bier, for his work with new methods in surgery, and Professor Ferdinand Sauerbruch, for his work in the sur-

gery of the lungs; the third award was given to Dr. Wilhelm Filchner, who has led exploring expeditions into Mongolia and Tibet.

Nature states that the honorary degree of doctor of science has been conferred by the University of Birmingham on Dr. C. C. Paterson, director of the Research Laboratories of the General Electric Company, "in recognition of his many contributions and services to electrical science." Dr. Paterson was for sixteen years a member of the staff of the National Physical Laboratory, where he established and administered the Electrotechnics and Photometry Divisions of the Laboratory until 1918. He then under Lord Hirst initiated the General Electric Company Laboratories at Wembley. His chief personal contributions and scientific papers have been in the fields of light and lighting.

THE decoration of chevalier of the Legion of Honor of the French Republic has been conferred on George E. Pearson, the governing director of the Wellcome Foundation, Ltd.

THE Medical Association of Kinesiology at Buenos Aires has elected Dr. Max Westenhöfer, professor of general pathology and pathological anatomy in the University of Berlin, as an honorary member.

HENRI PITTIER celebrated his eightieth birthday in Caracas, Venezuela, on August 13. The Secretary of Education of Costa Rica directed to him a letter of congratulation, and of appreciation of his long years of scientific and educational labor in that country. He ordered also that an account of his work should be given on August 13 in all the secondary schools. A session of the Rotary Club of San José in honor of the occasion was attended by numerous government officials and many representatives of scientific and educational circles.

DR. OTIS W. CALDWELL, general secretary of the American Association for the Advancement of Science, was elected at the meeting at Tokyo of the World Federation of Education Associations chairman of the newly organized International Association of Science Teachers. H. A. Carpenter, specialist in science in the schools of Rochester, N. Y., was elected secretary.

DR. OSCAR V. BRUMLEY, dean of the College of Veterinary Medicine of the Ohio State University, was elected president of the American Veterinary Medical Association at the recent convention held in Omaha, Nebr.

AT the Pennsylvania State College and Agricultural Experiment Station the retirement is announced of Frank D. Gardner, head of the department of agronomy for twenty-nine years, and of J. A. Ferguson, head of the department of forestry for twenty-seven years. Dr. A. L. Patrick, professor of soil technology and soil technologist at the college, has become associated with the Soil Conservation Service of the U. S. Department of Agriculture.

KNOWLES A. RYERSON, in charge of sub-tropical food investigations at the office at Riverside, Calif., of the Bureau of Plant Industry, has been appointed professor of agriculture and director of the branch of the College of Agriculture of the University of California at Davis. Eugene L. Jack has been appointed assistant professor of dairy industry, and Louise C. Struve, assistant professor of home economics.

DR. RAOUL L. MENVILLE, a member of the department of chemistry at the Louisiana State University since 1906, will take up his work as dean of the College of Pure and Applied Science at the opening of the college year. He takes the place of Dr. Charles E. Coates, who, according to the policy of the university, retired on reaching the age of seventy years, with the title dean emeritus.

DR. FLOYD L. RUCH, of the Pennsylvania State College, has become associate professor of psychology at the University of Southern California.

MAYNARD W. QUIMBY, graduate student and instructor in botany at Cornell University for the past four years, has been appointed instructor in botany at the University of Maine.

DR. N. F. CHILDERS has been appointed a member of the staff of the department of horticulture at the Ohio State University. He succeeds Professor W. Paddock, who has retired.

DR. WERNER KUHN, of Carlsruhe, has been appointed professor of physical chemistry at Kiel in succession to Professor Schwarz, who has become professor of chemistry at Königsberg.

D. J. BAUER, of Trinity College, University of Cambridge, has been elected to the Michael Foster studentship in physiology.

THE following scholars from abroad will join the faculty of the University of Notre Dame, Indiana: Canon Georges Lemaître, professor of mathematics and theoretical physics at the University of Louvain; Dr. Kurt Godel, of the University of Vienna, and Professor Emil Artin, of the University of Hamburg. They will join Dr. Karl Menger and Dr. Arthur Haas, both formerly of the University of Vienna. In addition, Dr. Eugen Guth, also of the University of Vienna, has accepted a teaching fellowship for the coming year and will collaborate with Dr. Haas in a series of special research problems.

HARRY T. DAVIS, associate director and curator of

geology at the North Carolina State Museum, has been appointed director of the museum by the commissioner of agriculture. Mr. Davis succeeds H. H. Brimley, who has been head of the museum for the past forty-two years. Mr. Brimley becomes curator of zoology.

FRANK M. SETZLER, acting head curator of anthropology at the U. S. National Museum since the death of Walter Hough, has been appointed head curator.

DR. P. N. ANNAND has been made special research assistant to the chief of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. C. M. Packard will succeed him as chief of the Division of Cereal and Forage Insect Investigations.

DR. C. M. HOUCK, formerly manager of the inspection division of the Pittsburgh Testing Laboratory, has been elected vice-president. His predecessor in the vice-presidency, A. R. Ellis, was recently elected president.

DR. R. D'E. ATKINSON, associate professor of physics in Rutgers University, has been appointed chief assistant in the Royal Observatory, Greenwich. A correspondent writes: "Dr. Atkinson has always been interested in astrophysical problems and his work on atomic synthesis and the source of stellar energy was of particular importance. In the course of this work he deduced, at a time when the neutron had not been discovered, from general considerations of atomic abundance in the sun and stars that there must be some type of particle that could penetrate a highly charged nucleus more easily than a proton." Dr. Atkinson was a member of the Harvard College Observatory Eclipse Expedition to Siberia in 1936.

LORD MOYNE, a vice-president of the Zoological Society of London, is leaving England in his yacht, *Rosaura,* taking with him another member of the council of the society, M. Jean Delacour, who is the owner of some private zoological gardens at Clères, Normandy. M. Delacour is especially interested in live humming birds and is taking with him elaborate apparatus for collecting and keeping them on board the yacht. In addition to collecting animals for the London Zoological Park, Lord Moyne will study the culture and mode of living of the aboriginal Indians who live in the hinterland of British Guiana close to the Venezuelan frontier.

AMONG those attending the tenth meeting at Lisbon of the International Union against Tuberculosis were Dr. Kendall Emerson, managing director of the National Tuberculosis Association, a member of the executive committee of the International Union; Dr. Robert E. Plunkett, general superintendent of tuberculosis hospitals, New York State Department of Health; Dr. Charles J. Hatfield, director of the Phipps Institute of Philadelphia, secretary of the National Tuberculosis Association; Frederick D. Hopkins, executive secretary of the National Tuberculosis Association; Dr. B. S. Pollak, head of the Hudson County (N. J.) Tuberculosis Hospital, and Dr. Abraham E. Jaffin, of Jersey City.

THE London *Times* states that the Soviet press reports the dismissal of Dr. Gorbunoff, secretary of the Scientific Academy of Moscow, and the liquidation of his Commission of Examiners, in consequence of the discovery that certificates had been granted by favor without examination to students possessing no algebra and imperfect Russian. Dr. Gorbunoff, who is forty-five years old, was private secretary and secretary of the Council of People's Commissars in 1917, manager of the Council of Labor and Defense in 1920, leader of the Soviet-German expedition to the Pamirs in 1928 and vice-president of the Academy of Agricultural Sciences in 1930.

A PRIZE of $1,000 and a gold medal for outstanding achievement in milk chemistry has been established by the Borden Company. The award will be made annually for three years beginning in 1939 under the direction of the American Chemical Society. Establishment of the prize was sanctioned by the society at the Rochester meeting on the recommendation of a committee consisting of Dean Frank C. Whitmore, of Pennsylvania State College, president-elect of the society; Erle M. Billings, of the Eastman Kodak Company, and Professor Arthur J. Hill, of Yale University, both of whom are directors of the society.

A SANITARY engineering research laboratory and section station on University Heights, New York City, which will be conducted jointly by New York University and New York City, will be dedicated on September 20. Mayor La Guardia, Lieutenant Colonel Brehon B. Somervell, Works Progress Administration administrator of New York City, and Dr. Thorndike Saville, dean of the College of Engineering of New York University, will be the principal speakers. In a statement issued in regard to the laboratory Dean Saville said that the new laboratory constitutes a "unique development in cooperation between a large city department and a private educational institution. The Department of Sanitation in New York City and the New York University College of Engineering have effected an agreement whereby each of the parties is enabled jointly to further specific objectives in a more comprehensive manner than either could achieve alone."

THE Rockefeller Foundation, which has conducted work on health projects at Kingston, Jamaica, for more than eighteen years, will retire this month. Its headquarters will be transferred to Havana. Dr.

Benjamin E. Washburn, head of the West Indies branch of the foundation, has received the formal thanks of the government for the work of the foundation, which has resulted in a decreased death rate and other benefits.

LORD NUFFIELD, who recently made a gift of £5,000 to the National Hospital for Nervous Diseases, Queen Square, London, for the building of a new research department, has made a further gift of £24,000 for the same purpose. The rebuilding scheme was made possible by the offer of the trustees of the Rockefeller Foundation to give £60,000 towards rebuilding the laboratories, the department of pathology and the surgical unit, and £60,000 for the endowment of research work, provided that a similar amount be raised by December 31.

AN Associated Press dispatch printed in the *Los Angeles Times* states that the Norwegian iceship Gudrun returned on September 4 from the Arctic with a receptacle, which it is believed contains the diary of the Swedish explorer, Salomon August Andree, who was lost on an attempt to reach the North Pole by balloon forty years ago. The copper and cork container was found on a small island near Spitzbergen by a fisherman. The diary is said to be in good condition.

AN aeronautical museum has been established at Ottawa with the purpose of illustrating the development of aviation and particularly the part Canada has played in this development. *Museum News* states that a large hall in the basement of the National Research Building has been set aside for the museum and exhibits are now being installed. The material already acquired includes exhibits dealing with the work of Alexander Graham Bell in aeronautical science and in practical flying. So far all exhibits have been donated and necessary cases have been paid for out of funds of the National Research Council. Organizations cooperating in the establishment of the museum are the National Research Council, the Associate Committee on Aeronautical Research of the Council, the Canadian Flying Clubs Association, the Canadian Department of National Defense and the Civil Aviation Branch of the Department of Transport.

FIFTY-TWO survey and exploratory parties were placed in the field this year by the Mines and Geology Branch, Department of Mines and Resources, Ottawa. Forty-one of these parties have been engaged in geological investigations and eleven in topographical mapping. The field force, of about 300 men, worked every mineral producing province in the Dominion, and in Yukon and the Northwest Territories. Nine geological parties were sent to British Columbia, while Ontario and Quebec each had seven. The Prairie Provinces had eleven; the Maritime Provinces four; the Northwest Territories two, and Yukon one. Three topographical parties have worked in British Columbia, three in Alberta, two in the Northwest Territories, and Ontario, Nova Scotia and Yukon each have one. The National Museum of Canada placed nine parties in the field for the purpose of making investigations dealing with the migration and nesting habits of Canadian birds; the distribution of plant and animal life, and the preservation of game, particularly in the Northwest Territories. In addition, ethnological studies were planned of certain Indian tribes. In this last connection excavations have been made in a number of old Indian village sites in Quebec and in Prince Edward Island.

DISCUSSION

OBSERVATIONS OF A BRILLIANT AURORA

ON the night of August 1 to 2, while obtaining spectrograms with the 69-inch reflector of the Perkins Observatory, I stepped out on the deck to the northeast at five minutes past midnight, E.S.T., to look for Finsler's Comet. My attention was immediately arrested by an unusually brilliant display of the Aurora Borealis. At this moment two distinct arches were visible, of which the lower was the brighter and the more irregular in outline. Several bright streams of different widths and intensities projected upward from the north point, like beams from a giant searchlight. The two arches gradually merged into one.

At 12:15 A.M. the streamers were much more brilliant and numerous. Eighteen were counted, and in addition several fainter ones were suspected. Some were several degrees wide, and some were not more than half a degree in width. The brightest extended fully forty-five degrees above the horizon. No motion was apparent at this time, the streamers simply brightening and gradually fading away. Most of the auroral light was of the customary white color with pale greenish tinge. However, the brightest group of streamers, rising in the north-northeast, was distinctly pink in hue. The intensity of the color increased toward the extremities of the streamers, where they appeared quite red.

At 1:25 a brilliant white bow was observed projected like the beam of a powerful searchlight across the zenith from west by north to east by south. It

extended almost from horizon to horizon. At this instant the western half of the bow was very bright. Gradually this portion split into two fainter bows, while the eastern half increased in intensity until its light predominated. A slow, swirling movement was detected in the portion of the bow overhead as it drifted lazily southward. Fully fifteen minutes passed before the bow disappeared.

At 1:40 the upper arch across the northern horizon faded, while the lower one increased in intensity. It became extremely bright, rising to a height of fifteen degrees at its greatest altitude. Since the area beneath it was quite dark it appeared unusually brilliant by contrast. It was most irregular in outline, being shot through and through with streamers both dark and bright. Never before have I seen an arch which resembled so closely the pictures of aurorae as observed in polar regions. As I watched, bright arches suddenly formed at an altitude of twenty degrees above the north. Almost instantly they rose to a height of some thirty degrees, where they vanished. Arch after arch appeared, sped upward, and vanished. Their behavior was similar to that of the high-voltage coronal discharge between vertical, nearly parallel metallic bars, in which the flaming arc is carried upwards by convection currents arising from its own heat. At the same time bright areas flashed forth here and there all over the northern sky, giving the appearance of far-away lightning reflected from numerous clouds. This lively activity continued for five minutes and slowly subsided, leaving only the bright lower arch and several vertical streamers.

At 2:00 the northern arch was very bright. It extended some forty-five degrees across the horizon, and its central boundaries lay ten degrees and twenty degrees above the north point. Numerous brilliant, cloud-like areas were seen above it, interspaced by irregular dark streaks which gave the appearance of moonlight coming from behind clouds of varying density. (The weather map, prepared a few hours after these observations, showed no clouds within two hundred miles to the north of us.) Several wide and somewhat indefinite streamers rose almost to the zenith where they blended with the Milky Way.

At 3:15 both northern arches were very bright. They extended along the horizon forty-five degrees and sixty degrees respectively and rose to central altitudes of fifteen degrees and twenty-five degrees respectively. In the north-northeast a brilliant white shaft one and one half degrees wide extended fully sixty degrees above the horizon in spite of illumination now introduced by the crescent moon which was now well above the horizon. Ten minutes later the bright shaft had faded away. In its place was seen a dark streak fully five degrees wide which extended up through both arches. The lower arch then increased greatly in brightness. Simultaneously the upper arch dimmed and disappeared. At this time arcs began to rise again in a fashion similar to that noted at 1:40. For several minutes they swept upward, taking about one third of a second to reach the position formerly occupied by the upper arch. There they vanished instantly.

At 3:55 the two bright arches were seen again, and eleven sharp streamers about one degree in width could be followed to a height of forty-five degrees above the horizon where they faded off into the moon-lighted sky. They dimmed slowly until only two were left, one northeast and the other north-northeast. Each was about two degrees wide.

Finally at 4:25 the upper arch and the eastern half of the lower ones were lost in the light of the coming dawn. The western half of the lower arch was still very bright, and in the north one brilliant streamer two degrees wide could be followed upward as far as Polaris.

The display evidently began between 11:45 o'clock and midnight, and it probably continued for some time after the light of the rising sun obscured it from our view. Since, of course, most of my time during the night was devoted to tending the spectrograph and adjusting the telescope, I undoubtedly missed a large part of the phenomenon. However, the above account is probably a fair sample of what took place. When one recalls that the Perkins Observatory is located in latitude forty degrees north, it is evident that a magnificent sight must have been presented in the higher latitudes of North America on that night.

The following day I observed the sun with a small telescope and found on its disc three large groups of spots and several isolated spots of moderate size. The group containing the largest sun-spot of all occupied a position southwest of the center of the disc. The position of this spot was such as to indicate that it had passed near the center of the disc some twenty-four hours before the display was observed.

No recurrence of the phenomenon was noted during the following night, although the northern sky was scanned many times.

ERNEST CHERRINGTON, JR.

PERKINS OBSERVATORY
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PROGRESS IN THE CONTROL OF WHITE PINE BLISTER RUST

THE director of the Brooklyn Botanic Garden in a recent interesting article[1] on the scientific value of botanic gardens refers to several problems in forest pathology. Among the comments on white pine blister rust occurs this sentence: "The only way yet known

[1] C. Stuart Gager, SCIENCE, April 23, 1937.

to keep this disease in check is to destroy all the currant and gooseberry bushes within a radius of many miles of any white pine—a drastic and difficult procedure, and only partially possible."

We are glad to inform readers of SCIENCE that the blister-rust-control situation is much more encouraging than Dr. Gager's comment would indicate. A number of years ago it was found that the sporidia produced on the leaves of currant and gooseberry plants (*Ribes*) are very delicate and normally do not cause commercial damage to pine under average forest conditions to a distance of more than 900 feet from the *Ribes* plant. Therefore, local control of the disease is accomplished by destroying all *Ribes* within 900 feet of white pines and keeping the *Ribes* suppressed on such areas. In addition, the European or cultivated black currant is eliminated throughout white pine regions as a general control measure, because it is more susceptible to the disease than other *Ribes* species and is the chief agent in the long-distance spread and establishment of the rust in uninfected areas. This is not a native plant, has not escaped from cultivation to any extent, and accordingly can be located without serious difficulty and eradicated.

Control of blister rust is entirely practicable and economical. Individual pine stands can be protected by the removal of *Ribes* in their immediate vicinity, and this measure is successful in controlling the disease locally, regardless of the possible neglect of such work in surrounding stands or the presence of centers of infection nearby. The protection of valuable stands of five-leafed pine has gone forward at a rapid rate, particularly since 1933, when emergency relief labor and labor from CCC camps became available for this work. Excellent progress has been made in the protection of all three of the commercially valuable species of susceptible pines in the United States, the northern white pine, *Pinus strobus,* extending from the Lake States to Maine and southward along the Appalachian Range to northern Georgia; the western white pine, *P. monticola,* occurring chiefly in Idaho, eastern Washington and western Montana; and the sugar pine, *P. lambertiana,* extending along the Cascade and Sierra Nevada Mountains from southern Oregon to the vicinity of Sequoia National Park in California.

These three species occur in stands sufficiently dense to be of commercial value on about 15,000,000 acres of land. The 900-foot-border zones increase the acreage of the control areas from which the *Ribes* must be removed to something over 26,000,000 acres. By the end of 1936, an aggregate of over 18,000,000 acres of these control areas had been given one working and the *Ribes* removed. From 12,000 to 20,000 men, largely from relief rolls and from CCC camps, have been employed on the work during each of the last four summers. Prior to that time the work was conducted on a much smaller scale for several years in cooperation with the states, counties and private owners concerned.

Control of white pine blister rust is carried on under the leadership of the Bureau of Entomology and Plant Quarantine, which is cooperating with the Forest Service, the National Park Service, the Indian Service, the Works Progress Administration and other federal, state and private agencies owning or administering forest land. This project has been in progress long enough so that it is possible, by comparison of protected areas with unprotected areas, to be sure that the control methods used are proving entirely effective. There is some regeneration of *Ribes* after eradication, and portions of the control areas must be gone over again in from three to ten or more years, depending on local forest and *Ribes* conditions. Present indications are that pine stands can be protected, from the seedling stage to maturity, by working the areas for *Ribes* from one to three times. The destruction of *Ribes* promptly stops the increase of infection in pine stands, regardless of the amount of infection that may have occurred before the work was begun, although such trees as are already fatally infected do not recover. Not all infected trees die, branches with blister rust cankers occasionally being shaded out before the canker reaches the trunk, but the disease is fatal when, as is usually the case, either trunk cankers or very numerous branch infections are present.

The extent to which relief labor will continue to be available for conservation work of this kind and the possibility of continuing operations to cover remaining unprotected pine stands can not, of course, be determined at this time, but in any event the protection already given to millions of acres of valuable white pine helps to conserve a forest resource of great value to the public for timber, recreational and water-supply purposes that would otherwise have suffered the fate of the chestnut.

S. B. FRACKER

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DOES THE VIRUS OF INFLUENZA CAUSE NEUROLOGICAL MANIFESTATIONS[1]

THERE has been a great deal of discussion in regard to the possible relationship between influenza and encephalitis or encephalo-myelitis. In this paper for the sake of brevity, the term "encephalitis" will be used with the understanding that it may refer either to a pure encephalitis or to an encephalo-myelitis. In this brief report no attempt will be made to cover the details of the various arguments that have been advanced.

[1] Preliminary report.

It may be well to point out that in Jordan's[2] study of the epidemiology of influenza, the conclusion was reached that any connection between these two diseases was probably fortuitous.

It is well recognized that, except in times of epidemic, the diagnosis of influenza is often loosely made. Since the discovery of the virus of influenza, it has been possible to make the diagnosis with a high degree of accuracy by the study of the neutralizing power of the serum after convalescence.

During the past several months, a certain number of cases have come to our attention in which an acute respiratory infection diagnosed as grippe or influenza has been followed within a short time by the development of various neurological conditions. In sixteen such instances the serum of the patients has been obtained within one to three or four months after the upper respiratory infection. These serums have been tested for influenzal antibodies according to the procedure of Francis and Magill.[3] In fourteen instances no protective antibodies were demonstrated in the serums. In one instance, the serum virus mixtures indicated slight protection and in one instance, a partial protection. In no instance was there complete protection. It, therefore, seems reasonable to assume that the original diagnosis of influenza or grippe had been incorrect in at least fifteen of the cases.

Further indications that the virus of influenza is not an etiological factor in cases of encephalitis or encephalo-myelitis is afforded by two facts: first, in a personal communication Francis has stated that in experimental animals the virus of influenza does not invade the central nervous system; second, Dr. L. S. Snegireff, of the New Jersey State Health Department, has given me permission to quote him to the effect that in investigating several New Jersey state institutions, where epidemics of influenza have occurred, there has been no instance in which encephalitis has developed during or following the outbreaks of influenza.

These data indicate that there is no etiological relationship between encephalitis and influenza. It is obvious that further work must be done to confirm or refute this opinion.

Two questions arise which await further investigation. When encephalitis or encephalo-myelitis follows an upper respiratory infection (diagnosed as grippe or influenza), are these early symptoms the first stage of the central nervous system infection or does an upper respiratory infection (not influenza) lower the barriers of resistance of the naso-pharyngeal mucosa to a virus either latent or acquired? This latter question presupposes that the virus or viruses of encephalitis may gain entrance through the naso-pharyngeal mucous membrane. On this point there is no definite information. However, it is quite generally believed that this is the portal of entry of the virus of poliomyelitis and of the St. Louis type of encephalitis.

We hope that this brief report will lead to further investigations by others, and we trust that we shall have the opportunity to carry on more work.

JOSEPHINE B. NEAL
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[2] E. O. Jordan, "Epidemic Influenza," 1927; published by the American Medical Assn.

[3] Francis and Magill, *Jour. Exp. Med.*, 63: 5, 655–668, May 1, 1936.

THE OCCURRENCE OF A POSSIBLE MUTATION, CANCER TO NON-CANCER, IN THE HOUSE MOUSE

THE late Millard C. Marsh, in an attempt to demonstrate his theory that the irritation caused by intestinal nematodes (*Aspiculuris tetraptera*) was directly responsible for the appearance of mammary tumors in mice, developed a large colony of these animals in which the incidence of breast tumor was unusually high (80 to 100 per cent.). In support of his theory, he cited the behavior of these tumors when the experimental colony was freed from the parasites. In these mice he noticed that the tumor incidence was gradually becoming less and less.

Due to the fact that other workers, to whom he sent breeding stocks, of this strain, were unable to obtain the high tumor incidence recorded by Marsh an attempt has recently been made to determine the true incidence of cancer of the breast, in his stock.

In tabulating Marsh's data, it was noticed that this decline in cancer incidence among females of the worm-free colony was largely due to the inclusion, in the strain, of two families none of the members of which developed tumor. Tracing back the pedigrees of the first of these families, it was found that a mouse in his generation "Y," which itself had a mammary tumor and the female ancestors of which for 18 generations back had all been cancerous, gave rise to a line none of the members of which developed tumor. This line extended through twelve generations and contained 112 mice.

The female which gave rise to the second non-cancerous family was cancerous herself and had an ancestry of eight generations of tumor. All her descendants, which extended through eight generations and which numbered 28 females, were non-tumorous.

When these 140 animals are deducted from the data making up the incidence curve for the worm-free stock, the percentage of tumor remains remarkably constant in its range, for the different age periods (between 80 and 85 per cent.).

Unfortunately the stock, as it now exists in this

laboratory, is derived from a line which traces back to a generation above the points at which these changes occurred. Both of these non-cancerous families have been lost unless some one of the workers to whom Mr. Marsh sent mice, between 1930 and 1935, has continued the inbred line.

With two exceptions, we do not know to whom Mr. Marsh sent mice. We should be very glad to have such persons correspond with us.

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SPECIAL ARTICLES

CHANGES IN HUMAN TISSUE ELECTROLYTES IN SENESCENCE[1]

THERE are many reports of chemical alterations as animals increase in age up to maturity, but there have been few studies in which senescent animals have been compared with younger mature animals. We consider an animal to be senescent when it has lived three fourths of its maximum life span (taking one hundred years as the life span of humans) and that the younger mature animals used for comparison should be at least twice the age of sexual maturity.

For the analyses of human tissues which are reported in this paper two principal age groups were selected. The senescent group was seventy years old, or over, with an average of seventy-five years. The younger group, which served as a standard for comparison, consisted of individuals from thirty to forty years old, with an average of thirty-five years.

Tissues were obtained from autopsies, some from accident cases and others from pathological cases. These will be discussed separately. The accident cases[2] were people who appeared to have been in good health until killed suddenly by automobiles, by falling or by murder. Only those cases were analyzed where there had been a quick death uncomplicated by poisoning or intoxication. The analyses of eleven accident cases between the ages of thirty to forty years, with an average of thirty-five years, were taken as a standard for comparison with senescent tissues.

Table I represents the changes found in senescence. Tissues from six accident cases over seventy years old, having a mean age of seventy-five, were analyzed. Each value in Table I is the per cent. deviation from the standard values for younger tissues. It will be noted that, except for the heart water, there was an increase in water, chloride, total base, sodium and calcium. Furthermore, there was a decrease in potassium, magnesium, phosphorus, nitrogen and ash in all the tissues except the liver.[3]

TABLE I

PER CENT. DIFFERENCES IN ANALYSES OF HUMAN TISSUES FROM ACCIDENT CASES OVER SEVENTY YEARS OLD RELATIVE TO TISSUES FROM ACCIDENT CASES THIRTY TO FORTY YEARS OLD

Constituent	Kidney	Liver	Spleen	Psoas muscle	Heart	Average of tissues	
H_2O	+ 2.6	+ 1.7	+ 2.8	+ 0.8	- 1.4	+ 2.	XH
Cl*	+(2)	+(18)	+(12)	+(56)	+(25)	+(23)	
Total Base.	+ 3.	+ 12.	+ 4.	+ 6.	+ 7.	+ 7.	
Na	+ 5.	+ 15.	+ 21.	+ 62.	+ 0.3	+ 20.	
Ca	+60.	+ 4.	+ 14.	+ 33.	+ 31.	+ 28.	
K	-19.	+ 6.	- 13.	- 7.	- 9.	- 12.	XL
Mg	- 9.	+ 17.	- 10.	- 11.	- 2.5	- 8.	XL
P	-13.	- 0.1	- 8.	- 12.	- 2.	- 9.	XL
N	- 9.	+ 8.5	- 13.	- 3.	- 4.	- 7.	XL
Ash	-11.	+ 1.	- 8.	- 1.	0.	- 5.	XL

* The chloride values are less accurate than the other values in this table.
XH signifies that the average for the tissues does not include the heart.
XL signifies that the average for the tissues does not include the liver.

These changes in senescence were corroborated by our data on pathological cases obtained from autopsies in this department. Tissues from people over seventy years old were compared with tissues from people between thirty to forty years, all of whom died of disease. Eighty per cent. of the changes were in the same direction as those found with accident cases (Table I). These tissues were from patients who had died from the following diseases: carcinoma, nephritis, leuetic aortitis, brain abscess, arteriosclerosis and partial ileus. Pneumonia was a complication in three cases. Cases with severe infections or marked wasting were not taken and pathological organs were avoided as far as possible.

Partial further corroboration of the senescent changes was obtained by comparing another group of five pathological cases which were from sixty-five to seventy years old, with the young pathological cases. At this age only part of the changes were found, namely, those of total base, calcium, phosphorus and ash, with a moderate increase of chloride. On the other hand, these sixty-five to seventy year cases did not show significant changes of water, sodium, potassium, magnesium or nitrogen.

We do not consider these differences between old and young pathological tissues as being significant, except in so far as they substantiate the changes in old

[1] This investigation has been aided by a grant from the Josiah Macy, Jr., Foundation.

[2] The tissues from accident cases were obtained with the cooperation of Dr. Milton Helpern and other members of the Medical Examiner's Office of New York City.

[3] The values in Table I are calculated on a wet weight basis. When converted to a dry weight basis the positive values became even more significant, while the negative values became less significant. The nitrogen and ash did not decrease on a dry weight basis.

age found by the analyses of tissues from accident cases (Table I). In order to determine the effect of disease on the tissues the young pathological and accident cases were compared. Except for calcium, which was lower in the pathological tissues, there was a tendency toward changes in disease similar to those found in senescence. The magnitude of the changes in disease was less than in senescence, except in the case of magnesium. The present data do not warrant further comparisons. Extensive studies of tissue changes in selected diseases should be instructive. However, it is necessary to determine whether the differences found in tissues from patients dying of disease were produced progressivly with the advancement of the pathological condition or whether they arose in the terminal state preceding death.

These preliminary results are presented with no attempt to interpret their significance. Detailed analyses will be published after more data have been obtained. Only minor modifications of the average values for accident cases are to be expected as more tissues are analyzed. On the other hand, we do not claim that the analyses of pathological tissues are representative, but we feel that further work in that field would be profitable.

SUMMARY

Analyses of tissues from people over seventy years old who died from accidents were compared with analyses of tissues from thirty to forty-year-old people who also died from accidents. The old tissues contained more water, chloride, total base, sodium and calcium; and they contained less potassium, magnesium, phosphorus, nitrogen and ash than the younger tissue.

Tissues from pathological cases of the same two age groups showed the same changes after seventy years. Only part of these changes were found in tissues sixty-five to seventy years old.

Tissues from young pathological cases when compared with accident cases of the same age were found to have undergone changes similar to those found in senescence, but to a lesser degree. Calcium formed an exception.

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EFFECTS OF CARBOHYDRATE PLETHORA IN EXPERIMENTAL DIABETES

IN a recent study of carbohydrate metabolism[1] it was concluded that the depancreatized dog in the early stages of fasting was unable to oxidize administered glucose, since there was no fulfilment of the necessary criteria, *i.e.*, an elevation in respiratory quotient, a corresponding diminution in the amount of extra glucose excreted, a protein-sparing action and a ketolytic effect. Since the completion of that work Mirsky and co-workers reported that ketolytic[2] and nitrogen-sparing[3] effects were produced by injection of large amounts of glucose into depancreatized animals. The quantities administered were such as to lead one to expect glycogen formation, even in the absence of insulin,[4] although no data were reported on this point. Because of the suggestion that the deposition of glycogen in the depancreatized animal may result in oxidation of this material, we are reporting experiments on nephrectomized-depancreatized dogs conducted without anesthesia in order that respiratory metabolism, as well as blood constituents, could be studied.

Of nine operated animals, only three satisfactory preparations were obtained. In these, one kidney was removed and, ten days later, a loose tie was placed around the blood vessels of the remaining kidney at the time of pancreatectomy. Food and insulin[5] were administered to the animals until four days before the following experiment was conducted. A blood sample was drawn, functional nephrectomy was performed by tightening the kidney tie, and a basal metabolism period obtained for three to four hours. At the times noted in Table I blood was drawn and glucose injected intravenously. In the intervening time the animal was replaced in the chamber for determinations of the respiratory metabolism. Table I summarizes the data obtained on a single, representative animal. The absence of any significant change in the respiratory

TABLE I

EFFECTS OF GLUCOSE INJECTED INTO NEPHRECTOMIZED-DEPANCREATIZED DOG

Time after nephrectomy	Glucose injected	R.Q.	Blood constituents				Air Acetone
			Sugar	Acetone bodies	Non-protein N	Lactic acid	
hr.	gm.		mg. per cent.				mg./hr.
0	0		345	43	38	22	
4	0	0.73	430	49	55	25	51
11	25	0.72	1250	41	71	32	36
16.5	25	0.74	1727	33	83	38	23
21.5	25	0.74	2000	19	91	42	18
26	0	0.74	2022	10	94	45	13

[1] S. B. Barker, W. H. Chambers and M. Dann, *Jour. Biol. Chem.*, 118: 177, 1937.

[2] I. A. Mirsky, J. D. Heiman and R. H. Broh-Kahn, *Amer. Jour. Physiol.*, 118: 290, 1937.

[3] I. A. Mirsky, J. D. Heiman and S. Swadesh, *Amer. Jour. Physiol.*, 119: 376, 1937.

[4] S. G. Major and F. C. Mann, *Amer. Jour. Physiol.*, 102: 409, 1932.

[5] We wish to express our appreciation of the generous amounts of insulin supplied by the Eli Lilly Company.

quotient shows no oxidation of the administered carbohydrate, despite pronounced ketone- and nitrogen-sparing effects.

Carbohydrate values of the tissues obtained after the last respiration periods on this dog are shown in Table II, which includes, as controls, average figures previously reported from this laboratory.[6] It is evident that the administration of glucose caused deposition of appreciable amounts of glycogen, both in muscle and in liver. From the carbohydrate values obtained on the tissues, calculations, although only approximate, indicate that all the injected sugar can be accounted for.

TABLE II

TISSUE CARBOHYDRATES OF DEPANCREATIZED DOGS

Animal	Tissue	Glycogen mg. per cent.	Total fermentable carbohydrate plus lactic acid mg. per cent.
Nephrectomized-depancreatized, after 75 gm. glucose intravenously	Muscle	416	938
	Liver	845	2,982
Fasting depancreatized[6]	Muscle	71	266
	Liver	79	454

Some explanation other than carbohydrate oxidation must, therefore, be advanced for the nitrogen-sparing and ketolytic effects observed. It should first be pointed out that decreased protein catabolism is judged in this type of experiment solely on the basis of changes in blood non-protein nitrogen; any unmeasured retention of urea in the liver or in the muscles would give a false picture. Secondly, since protein is ketogenic in pancreatic diabetes, any lowering of protein breakdown might account for some of the ketone sparing. In any case, these changes may be attributed fully as well to the high glucose concentrations produced as to glycogen deposited. These experiments indicate that neither formation of glycogen nor establishment of high tissue carbohydrate levels facilitates the oxidation of sugar by the depancreatized dog.

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BRAIN METABOLISM DURING THE HYPOGLYCEMIC TREATMENT OF SCHIZOPHRENIA[1]

THE most interesting and perhaps the most important advance in the treatment of mental disease in many years is Sakel's[2] new treatment of schizophrenia. The amelioration which occurs as a result of his insulin treatment must be ascribed to functional changes in the brain. It is therefore of fundamental importance to examine the physiological effects induced in the brain after the intramuscular injection of large doses of insulin.

The present communication presents data concerning these changes in patients with schizophrenia receiving the insulin treatment. Though the investigation is not yet completed, the observations made thus far are adequate to indicate a possible mechanism for the alleviation. Cerebral metabolism was studied by determining the glucose and oxygen contents of the blood traversing the brain, blood samples being collected practically simultaneously from the internal jugular vein and the femoral artery. It was thus demonstrated that the oxygen utilization of the brain and therefore its metabolic rate are decreased during severe hypoglycemia. The average utilization of oxygen before the injection of insulin was 7.09 vol. per cent. (eighteen observations). During hypoglycemic coma the average cerebral uptake was 2.46 vol. per cent. (eleven observations), a fall of approximately 65 per cent. The average glucose uptake simultaneously decreased from 13.0 to 2.2 mg per cent. Since the brain oxidizes only carbohydrate,[3] insulin, in reducing the blood sugar, deprives the brain of its foodstuff. A diminished oxygen utilization is therefore secondary to lack of substrate.

This partial deprivation of energy of the brain finally leads to hypoglycemic coma; in most instances a necessary phase in the alleviation of schizophrenia. In the course of the production of this coma abnormal reflexes such as the Babinski appear finally to be succeeded by complete areflexia. The present studies also reveal that the Babinski sign appears at the time when a definite decrease in the oxygen utilization is noted; a more prolonged period of diminished energy supply leads to complete areflexia.

It is true that the metabolism of the entire brain, and perhaps the cord as well, is depressed as a result of hypoglycemia. However, the oxidations of different parts of the brain proceed at varying rates and since the energy requirements of the cerebral hemispheres are greater than those of the brain stem, medulla or cord, a diminished supply of energy would first be manifested in the functions of the hemispheres with

[6] W. H. Chambers, M. A. Kennard, H. Pollack and M. Dann, *Jour. Biol. Chem.*, 97: 525, 1932.

[1] From the Department of Physiology and Pharmacology, Albany Medical College, Union University, and Bellevue Psychiatric Hospital, Department of Psychiatry, New York University Medical College. This investigation was made possible by a grant from the Child Neurology Research.

[2] K. T. Dussik and M. Sakel, *Zeit. f. d. ges. Neur. Psych.*, 155: 351, 1936.

[3] H. E. Himwich and L. H. Nahum, *Amer. Jour. Physiol.*, 101: 446, 1932.

symptoms of cortical depression and subcortical release such as sweating, one of the earliest signs, and the Babinski. When hypoglycemia is prolonged further, the other parts of the central nervous system are progressively affected. The significance of the differential depression of the various parts of the central nervous system awaits further analysis. Nevertheless, the present results reveal the primary importance of the reduced metabolism of the brain in the alleviation of schizophrenia.

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CHEMICAL CHANGES OF FRUITS RIPENED IN THE PRESENCE OF ETHYLENE

THE physiological reactions of fruits ripened in the presence of ethylene have been interpreted in various ways. In some cases it has been considered that ethylene has a definite chemical effect, since more sugar, less starch and increased rate of respiration were observed in the treated fruit. In other cases, the experience has been that the effects of ethylene, if any, were more of a physical nature, since the only results observed after treatment were possibly an increased rate of softening and more rapid color development.

In experiments with pears and certain other fruits, the writer has found that ethylene definitely affects certain phases of the metabolism as well as the chemical composition of the fruit. These effects, however, have been obtained only during a definite stage in the life of the fruit. Thus, pears picked and treated with ethylene while still containing starch in the tissues had more reducing and total sugars and less starch than the untreated fruit. Pears treated at later stages of maturity or after being held in cold storage for short periods of time until the starch had disappeared, showed no increase in sugars as a result of ethylene treatment.

After starch hydrolysis has been completed in the fruit, it has been found that there is still a period of short duration when the softening of the fruit can be markedly accelerated by ethylene. That this increased rate of softening in the presence of ethylene is due to an acceleration of the pectic changes occurring in the cell walls is indicated. Before being ripened, pear fruits normally contain approximately 0.8 to 0.9 per cent. insoluble protopectin, but less than 0.1 per cent. of soluble pectin. During ripening the protopectin in the cell walls is hydrolyzed with a corresponding amount of soluble pectin appearing in the juice. These changes are accompanied by a definite softening of the tissues of the fruit. It has been found that these pectic reactions occur much more rapidly in the presence of ethylene than when this gas is withheld from the atmosphere surrounding the fruit. Thus, pears will contain 60 to 85 per cent. of the total pectin in the soluble form at the end of four to six days of treatment, while only a very small amount of soluble pectin has developed in the untreated fruit during this period.

Further evidence that ethylene accelerates the rate of protopectin hydrolysis has been obtained with fruits other than the pear. Gooseberries, for example, contained 54 per cent. of the total pectin in the soluble form at the end of four days' ethylene treatment, while the untreated fruit contained less than 0.1 per cent. of this amount. Green peaches exposed for a three-day period to an atmosphere containing ethylene developed five times more soluble pectin than the untreated lot.

A very marked pectic change resulting from ethylene treatment was observed in the rind of the Ponderosa lemon. Before treatment the rind of samples of this fruit, picked in a green condition, contained approximately 3 per cent. protopectin, but less than 0.1 per cent. soluble pectin. At the end of a fourteen-day period, the soluble pectin in the rind of the treated fruit had increased over 40 per cent., while the insoluble protopectin had decreased a corresponding amount. In the untreated fruit, however, there was only a slight increase in pectin and no noticeable decrease in protopectin.

The results of these experiments indicate that certain ripening changes, such as softening of the tissues, formerly referred to as "physical" in nature, are really a result of chemical changes which can be influenced by ethylene treatment.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW TYPE OF GNOMONIC RULER

A MODIFICATION of existing gnomonic rulers has been devised in this laboratory in an effort to shorten the time necessary to obtain gnomonic projections from Laue patterns. The method developed is suitable for such projection purposes and is capable of being applied to numerous similar problems. The design and operation of the ruler can be most clearly observed by examining the schematic diagram given in Fig. 1. The ruler consists of a plate so mounted on the Laue pattern that the entire ruler can be rotated about the center of the pattern, a straight edge always passing through the center. On this plate at a fixed distance from the center point of the pattern

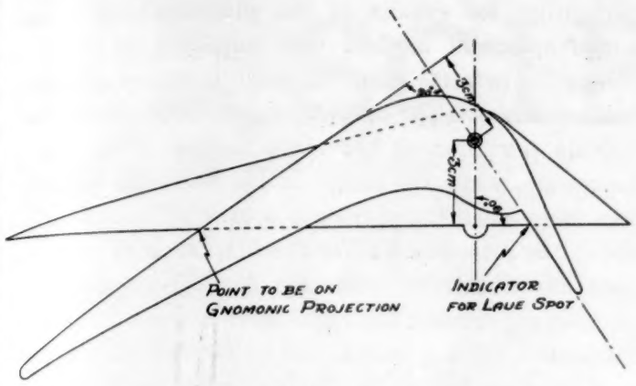

FIG. 1.

(C) in Fig. 2 is a small bearing holding a movable part, so designed that when one of its arms (CD) indicates the position of a Laue spot by its intersection with the straight edge, the other arm (AC) intersects with the straight edge at the correct position for the projected point.

To use the device, a pin is mounted through the small hole at (O) and through the center of the Laue pattern, which has previously been mounted on the sheet of paper intended for the gnomonic projection. The straight edge and the proper movable arm of the ruler are made to intersect at the position of the Laue spot and the corresponding point on the gnomonic projection is marked on the paper with the usual needle point. Rather complicated patterns can be transferred in this manner in a remarkably short time.

The theory is rather simple for the special case in which a definite distance, say c cm corresponds not only to the sample to film distance, but also to the radius of the fundamental circle of the gnomonic projection. Fig. 2 indicates the direction of the

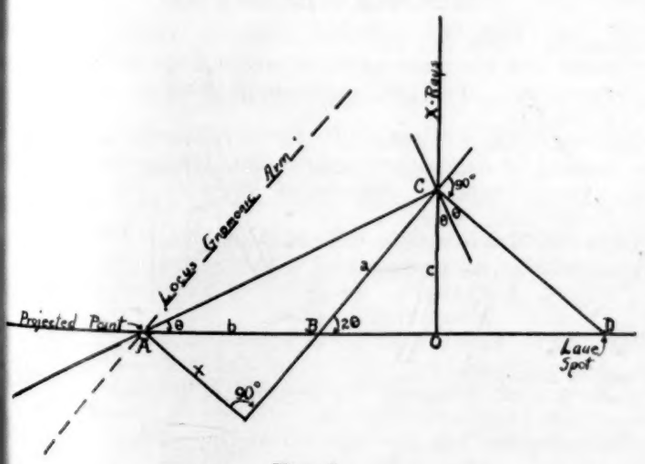

FIG. 2.

x-ray beam producing the Laue spot and shows where the gnomonic point for the same set of planes should lie. Since ABC is an isosceles triangle, b = a, but $\sin 2\theta = c/a = x/b$, so that c = x. It is evident that the arm intended to designate the position of the point on the gnomonic projection will be perpendicular to the indicating arm for the Laue spot, and at c cm above the bearing C. The bearing, of course, will lie c cm from the center of the Laue pattern at all times. Such a ruler as this can be made in a few moments from bristol board, using for the bearing a rather large eyelet, such as can be obtained from any stationery store. Suitable formulas can be derived for other more general cases, and the curve necessary for the gnomonic arm can be plotted on a piece of graph paper, and mounted on bristol board.

The necessary length of the indicating arms and of the straight edge depends upon the radius of the fundamental circle, and the size of the gnomonic projection desired. The accuracy with which points are located depends to a large extent upon the care used in properly placing the bearing.

Rulers such as this have been successfully employed in this laboratory, and make this type of projection a matter of only a few minutes rather than the somewhat tedious series of operations usually employed. For ordinary work we have found the special case at 3 cm to be very convenient.

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HYDROPONICS SOLUTION USED FOR DAPHNIA CULTURE

FOR the past year and a half we have had considerable success in raising *Daphnia* and other Crustacea and in maintaining cultures for long periods of time, using Gericke's hydroponics[1] solution as a culture medium. *Ankistrodesmus* developed rapidly in this solution and was consumed by the Crustacea. By employing the alternate aquarium method *Daphnia* cultures were kept going throughout the year. Besides *Daphnia pulex,* many other common aquarium forms have been successfully grown in this solution. The extremely common ostracods, *Cyprinotus incongruens* and *Cypridopsis vidua,* amphipods, copepods, planarians, snails and in fact all the usual inmates of aquaria thrive in this nutrient medium. Gericke's solution was also found to be excellent for growing *Elodea, Cabomba* and other aquatic plants to supply aquaria in our department. The added growth and vigor of the plants was noticeable within a day or two after transferring them to the culture medium. Recently, in order to show quantitatively the gain obtained by this method, we have made a series of controlled determinations of total organic matter, plankton counts and chemical changes, the results of which are given below.

In these experiments two five-gallon glass battery jars were placed in a window with a southern exposure,

[1] W. F. Gericke, SCIENCE, 85: 177, 1937.

one containing ordinary tap water and the other the solution used in hydroponics; 100 cc of a culture of *Ankistrodesmus* was added to each jar. Weekly determinations were made on each aquarium, the water or solution taken out being replaced each time and the loss due to evaporation made good by the addition of the tap water. One liter was run through a Foerst centrifuge and the organic matter determined by loss on ignition; a half liter was centrifuged for plankton counts. Methyl orange alkalinity, free carbon dioxide dissolved oxygen and pH determinations were made. A 14.0 cm length of *Elodea* was placed in each aquarium and the gain in length determined weekly. At the conclusion of the experiment the plants were dried and ashed to determine the organic matter in each.

The results expressed graphically are shown in Fig. 1. The graphs show strikingly the comparatively

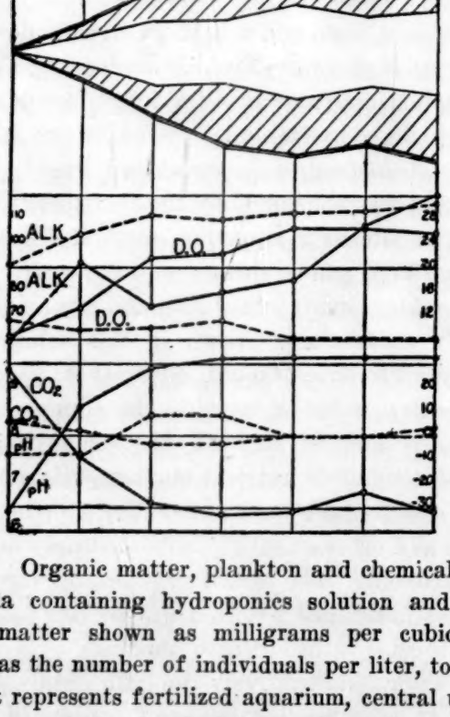

FIG. 1. Organic matter, plankton and chemical changes in aquaria containing hydroponics solution and control. Organic matter shown as milligrams per cubic meter; plankton as the number of individuals per liter, total vertical height represents fertilized aquarium, central unshaded portion the control; chemical figures in parts per million. Solid line represents fertilized aquarium, the broken line the control.

slight chemical changes in the control compared with the marked activity of the fertilized aquarium. In presenting the results of the plankton counts Lohman's spherical method was employed in order to bridge the extreme range between minimum and maximum numbers. The control ranged from 440,000 individuals per liter at the start to 440 million at its maximum, while the range in the fertilized aquarium was from 560,000 per liter to over 6 billion. *Daphnia* should be introduced after the first week or two or as soon as the culture becomes a decided green. In the present experiment the algae were allowed to multiply unchecked for six weeks, and at the end of that time, in fact long before it, the aquarium containing the culture medium was a very dark opaque green, while the control was barely tinged with a greenish color and perfectly transparent. The *Elodea* plants made their most rapid growth during the first part of the experiment due largely to the increasing green color in the culture solution and to the exhaustion of food from the control water. At the end of six weeks the plant in the culture was 32 cm in length and the control 25 cm; the condition of the two plants, however, showed great differences, the control being a sickly pale color with very short leaves on its terminal portion and no roots, while the other plant showed vigorous dark green leaves and numerous roots. The organic matter of the control amounted to 156.06 milligrams and that of the other plant 242.51 milligrams. It should be pointed out here that no soil was placed in either jar and this fact contributed to the very poor growth of the control plant.

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